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# Transactions of American Society for Steel Treating

Vol. V

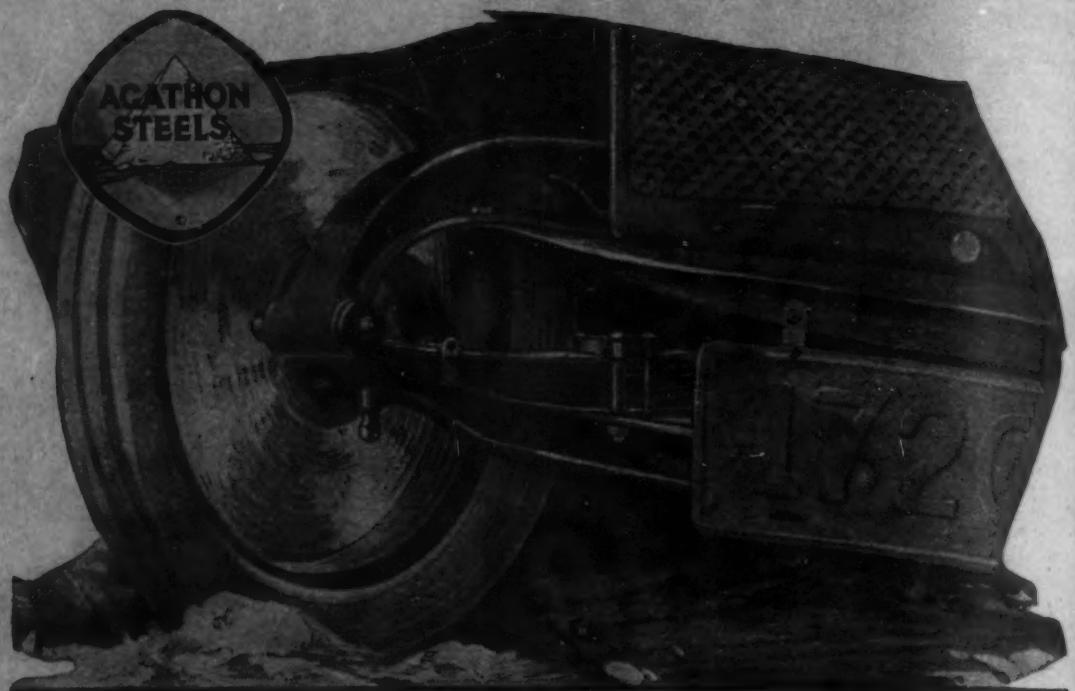
February, 1924

No. 2

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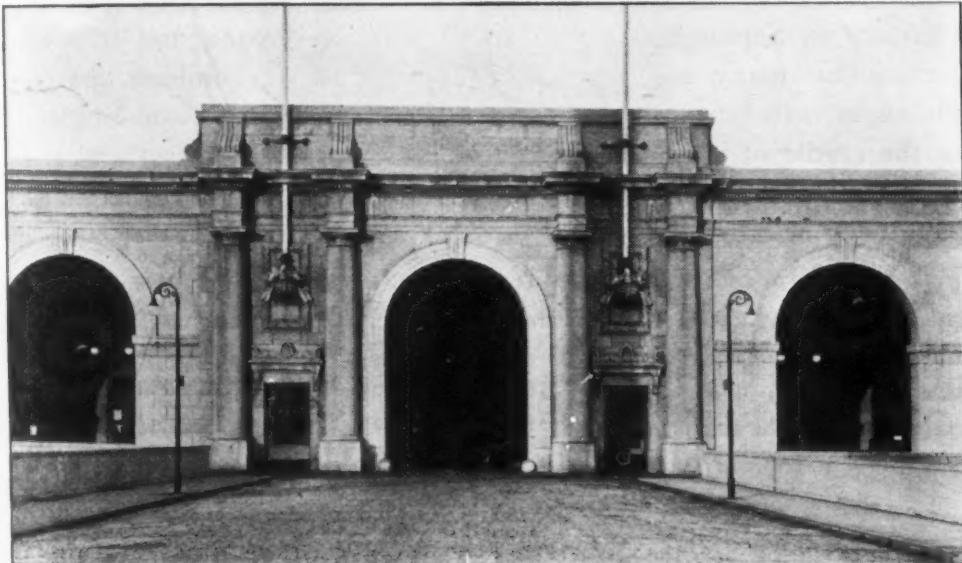
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**THE 1924 CONVENTION**

THE sixth convention and international steel exposition of the American Society for Steel Treating will be held in Boston the week of Sept. 22 to 26 inclusive. The decision was reached at the meeting of the board of directors of the society held in Washington, Nov. 2, but definite announcement has been withheld due to the fact that some difficulty was experienced in Boston in



Entrance to the Commonwealth Pier, Boston, where the Sixth International Steel Exposition will be held from September 22-26 inclusive.

securing a place with adequate facilities for holding the exposition.

Through the courtesy of Governor Channing H. Cox and Chairman William F. Williams, of the division of highways and waterways, permission has been granted the society to use the

Commonwealth pier for the exposition. This pier is ideally located and has wonderful facilities for the exposition. All of the spaces will be on one floor, as can be judged, from the dimensions of the pier, which is 120 feet wide by 1200 feet long. Floor plans have been drawn up and forwarded to the exhibitors who were with us last year in Pittsburgh, and will soon be given a general distribution. The complete co-operation of the state of Massachusetts together with that of the chamber of commerce of Boston assures every one that the convention and exposition this year will be the greatest gathering of iron and steel men ever witnessed in New England.

The program committee, under the direction of L. D. Hawkrige, held a meeting in New York in December and laid plans for convention papers and it is confidently expected that the papers will be of such caliber that the meeting will be more than comparable with the wonderful technical sessions held in Pittsburgh last year.

The selection of the dates in September was influenced by several conditions, one of the most important is that New England territory in September is ideal for touring purposes, and it is expected that many will accept the opportunity to combine vacation pleasures with business, and tour to the convention. New England, as the cradle of American history, holds more of interest and possible enjoyment than any other section of the country that might have been selected.

The New England chapters have all pledged their support to Mr. Handy, chairman of the Boston chapter to assist in making the 1924 convention not only of great local interest but of interest to all the New England states.

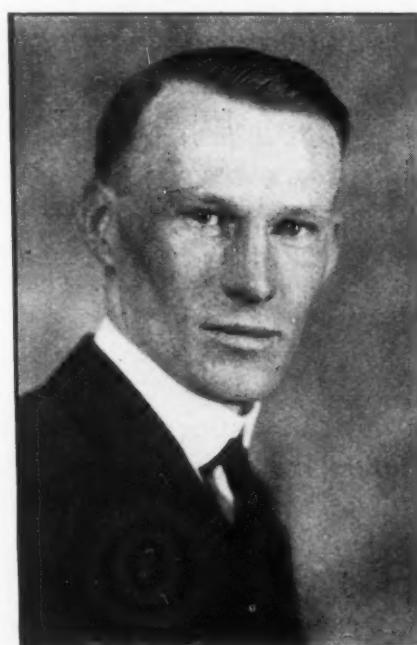
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#### NATIONAL COMMITTEE SECRETARY APPOINTED

**A**T THE meeting of the board of directors of the American Society for Steel Treating in Washington, Nov. 2, 1923, it was decided to secure a secretary for various national committees, in order to assist them in getting material together and relieve the chairman and members thereof of an excessive amount of detail.

Consequently, J. Edward Donnellan was appointed to the position and assumed his duties Jan. 15, 1924.

Mr. Donnellan was born in Cobalt, Conn., and was graduated as an industrial chemical engineer from Pratt Institute in Brooklyn, in 1918. After graduation, he was successively connected with New



J. EDWARD DONNELLAN

Department Mfg. Co., Bristol, Conn., as metallurgical chemist; then with the United States experimental station, Annapolis, as metallurgical assistant. His next position was with the Halcomb Steel Co., Syracuse, as assistant metallurgist, after which he became chief metallurgist and chemist at the Ohio Steel Foundry Co., Lima, Ohio.

Mr. Donnellan will undoubtedly receive the hearty support and co-operation of all the members of the Society.

## CARBON AND CARBON-VANADIUM STEEL CASTINGS —A COMPARISON

By J. M. Lessells

### Abstract

*This paper discusses the physical properties of carbon and carbon-vanadium steel castings as obtained from coupon test pieces in the cast, annealed and normalized conditions.*

*On the basis of these coupon tests evidence is given to show that the addition of vanadium as an alloying element greatly improves the quality of the material, more especially when tested under dynamic conditions.*

*The results discussed in this paper have been obtained in the research department of the company with which the author is associated.*

### INTRODUCTION

**I**N THE application of steel castings to a particular construction it is quite essential that the designing engineer know what can be expected from the material in either an annealed or normalized condition. Since little has been done on the dynamic testing of steel castings, this paper has been compiled in order to give comparative results for carbon and carbon-vanadium steel castings in the annealed and normalized conditions when tested statically and dynamically.

### MATERIAL

The material was obtained from the Union Steel Casting Co., Pittsburgh. The test pieces were cast in coupon form, integral to the body of a larger casting as shown in Fig. 1.

### ANALYSIS

The material was obtained from coupons cast in a given manner, the analyses of the steels being as follows:

Carbon Per Cent	Phos. Per Cent	Mn. Per Cent	Sul. Per Cent	Sil. Per Cent	Van. Per Cent
0.33	0.04	0.77	0.036	0.32	0.18
0.326	0.04	0.74	0.037	0.322	...

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A paper presented before the annual convention of the Society, Pittsburgh, October 8-12, 1923. The author, J. M. Lessells, is engineer in charge of mechanics, research laboratory, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

## TREATMENT

Both the carbon and carbon-vanadium steels were annealed by heating to 925 degrees Cent. (1700 degrees Fahr.) and cooling in

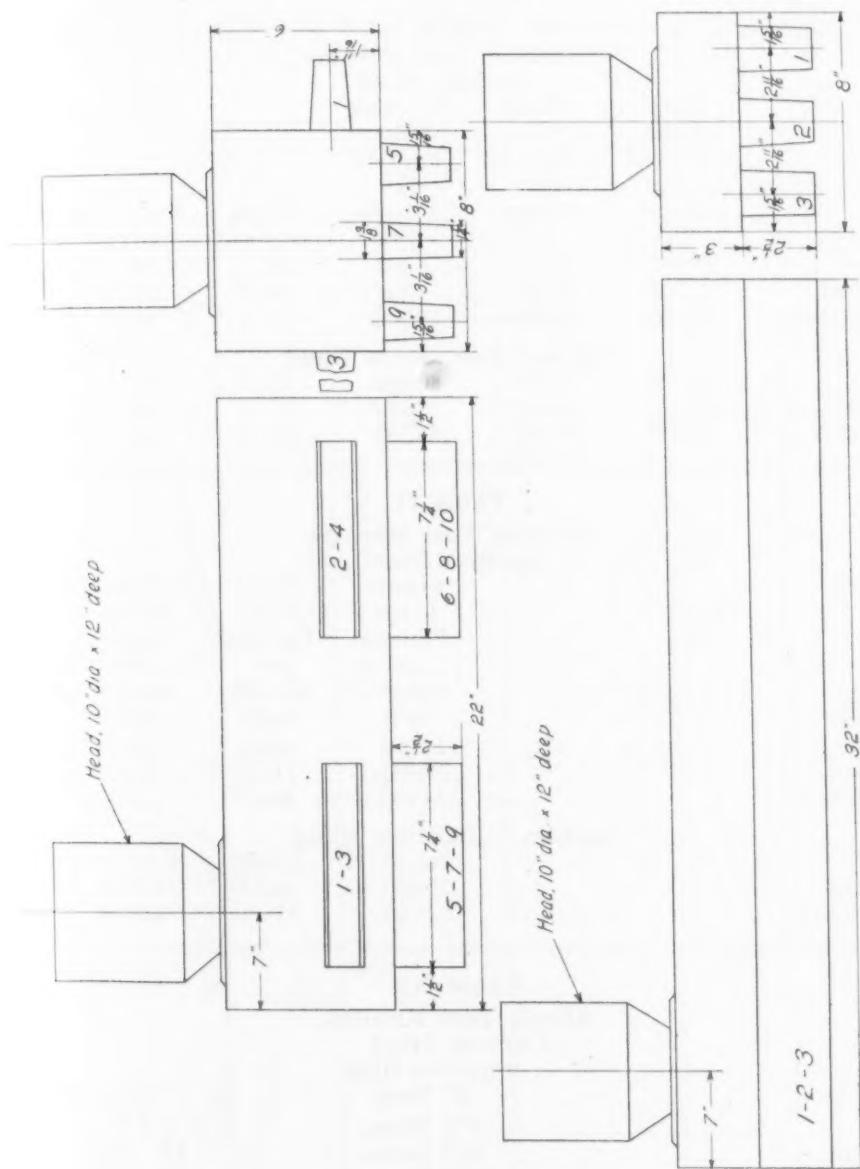


Fig. 1—Sketch showing the Method Used in Casting Test Bars for this Investigation.

the furnace and normalized by heating to 925 degrees Cent. (1700 degrees Fahr.) and cooling in the air.

## RESULTS

The tensile test results are given in Table I and were obtained on a beam type of machine. The torsion tests are given in Table II. The results of the shock tests from the repeated impact and

Table I  
Tensile Test Results  
Carbon Steel

Condition	Elastic Limit Pounds per square inch	Yield Point Pounds per square inch	Ultimate Stress Pounds per square inch	Elong. per cent	Red. Area per cent	Brinell No.
Cast.....	19900	33500	76200	26	34	141
Annealed.....	37100	41200	79800	26.8	39.5	143
Normalized.....	40500	45800	84900	27.6	45.6	163
<b>Carbon-Vanadium Steel</b>						
Cast.....	22500	37300	80800	23.6	29.6	156
Annealed.....	32100	40000	79600	27.5	43	152
Normalized.....	50600	52500	88700	26.4	46.7	162

Table II  
Torsion Test Results  
Carbon Steel

Condition	Elastic Limit Pounds per square inch	Yield Point Pounds per square inch	Ultimate Stress Pounds per square inch	Degrees Twist
Cast.....	24500	34600	60500	460
Annealed.....	25600	25800	59500	840
Normalized.....	24300	28470	62600	1025
<b>Carbon-Vanadium Steel</b>				
Cast.....	16500	23000	56900	697
Annealed.....	30400	34000	63000	694
Normalized.....	34760	38500	68500	1045

Table III  
Shock Test Results  
Carbon Steel

Condition	Repeated Blow 2" Drop	Single Blow
Cast.....	676 Blows	5.8 Foot pounds
Annealed.....	980 Blows	13 Foot pounds
Normalized.....	2000 Blows	18 Foot pounds
<b>Carbon-Vanadium Steel</b>		
Cast.....	760 Blows	6.6 Foot pounds
Annealed.....	1000 Blows	15 Foot pounds
Normalized.....	2000 Blows	18.7 Foot pounds

single blow impact machines are given in Table III, and the fatigue test values representing the average of those obtained from the beam and cantilever types of machines are given in Table IV. These machines have all been described in previous papers by the author, and, therefore, will not be detailed here. In Figs. 2, 3, 4, 5 and 6, these values are shown in graphical form.

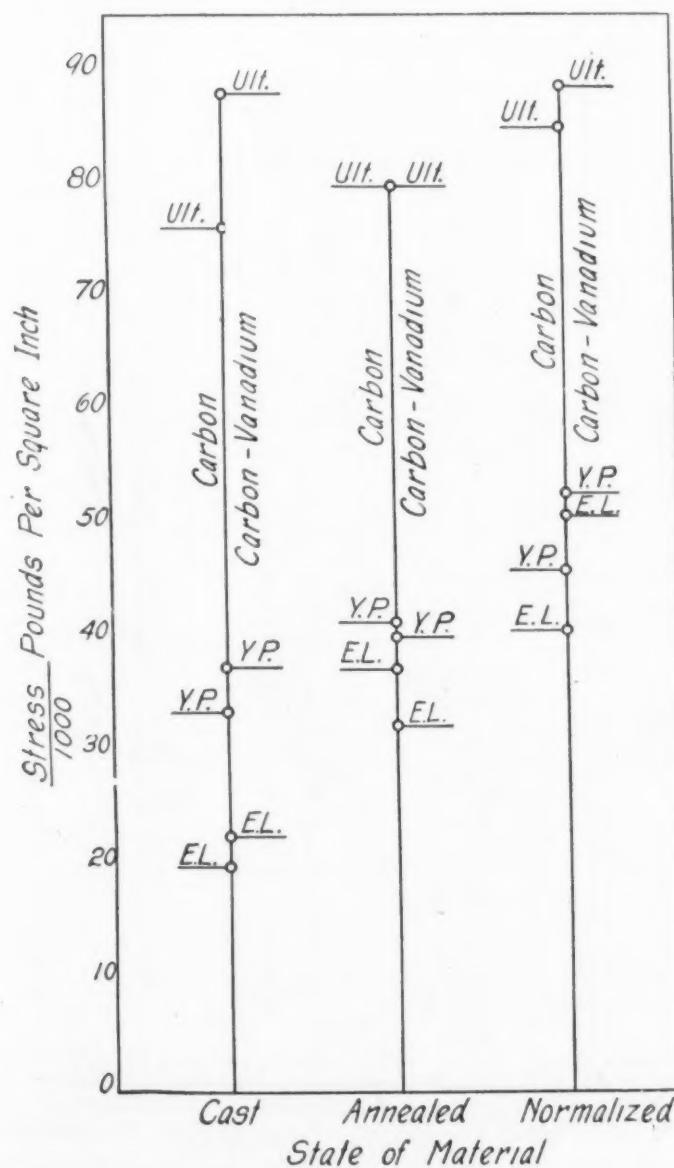


Fig. 2—Tension Tests of Carbon and Carbon-Vanadium Steels in the Cast, Annealed and Normalized Conditions.

## DISCUSSION OF RESULTS OF TENSILE TESTS

The torsion test values are very interesting in that annealing and normalizing have little effect on the elastic properties of carbon steel, but show a very decided increase in those for the carbon-vanadium steel. The angle of twist before break down is, however, greatly increased by the normalizing operation. The carbon-

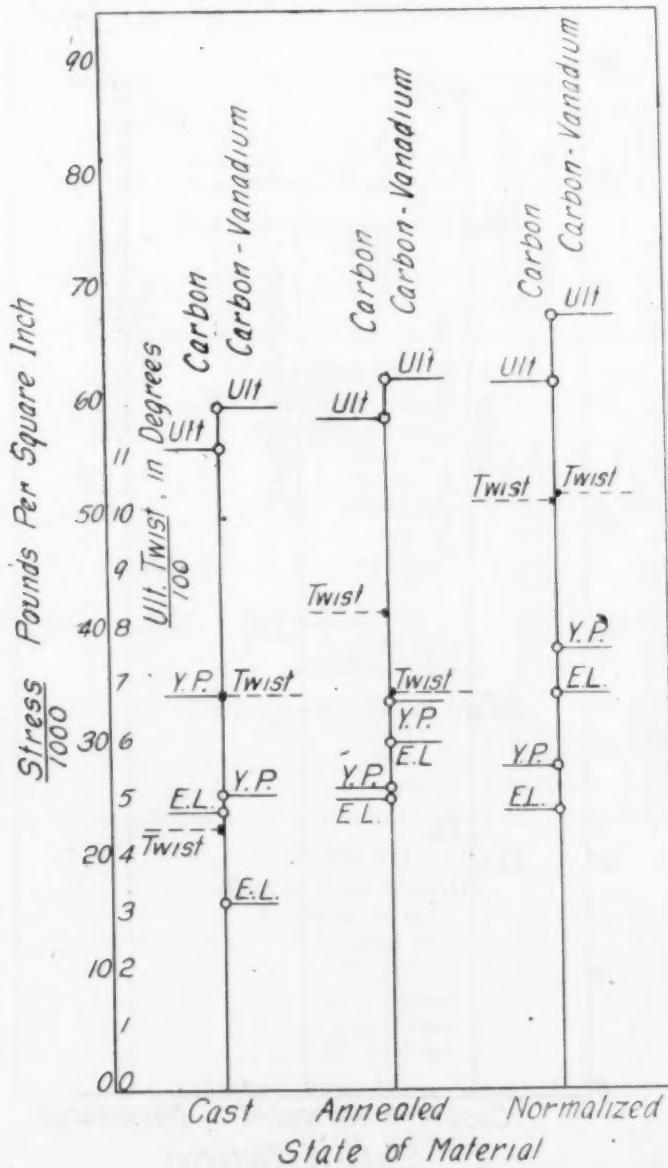


Fig. 3—Torsion Tests of Carbon and Carbon-Vanadium Steels in the Cast, Annealed and Normalized Conditions.

vanadium steel shows up decidedly better than the carbon steel, as regards elastic properties. (Fig. 3).

#### SHOCK TEST

The shock test results taken from both the repeated blow and single blow machines are in agreement in showing that there is a

Table IV  
Fatigue Test Results  
Carbon Steel

Condition	Endurance Limit pounds per square inch
Cast.....	32000
Annealed.....	36000
Normalized.....	36000
<b>Carbon-Vanadium Steel</b>	
Cast.....	39000
Annealed.....	42000
Normalized.....	42000

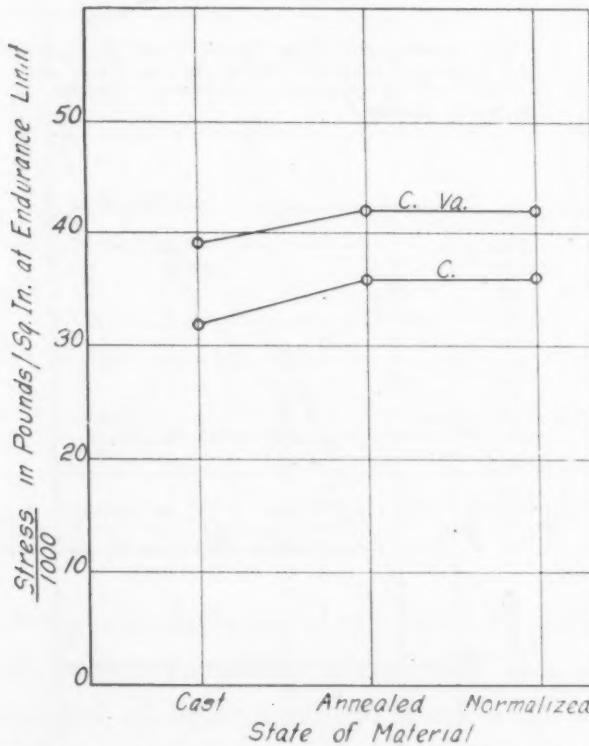


Fig. 4—Endurance Tests of Carbon and Carbon-Vanadium Steels in the Cast, Annealed and Normalized Condition.

great increase in resistance to shock by annealing and a further increase by normalizing, but that carbon and carbon-vanadium are essentially the same. (Figs. 5, 6 and 7),

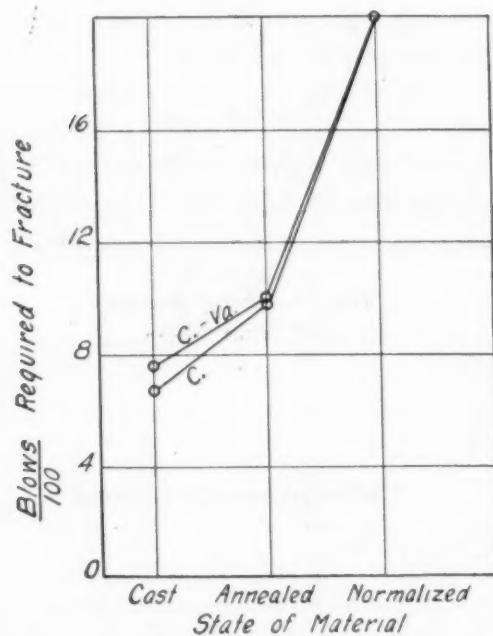


Fig. 5—Repeated-Blow Shock Tests of Carbon and Carbon-Vanadium Steels in the Cast, Annealed and Normalized Conditions. Height of Drop—2 Inches.

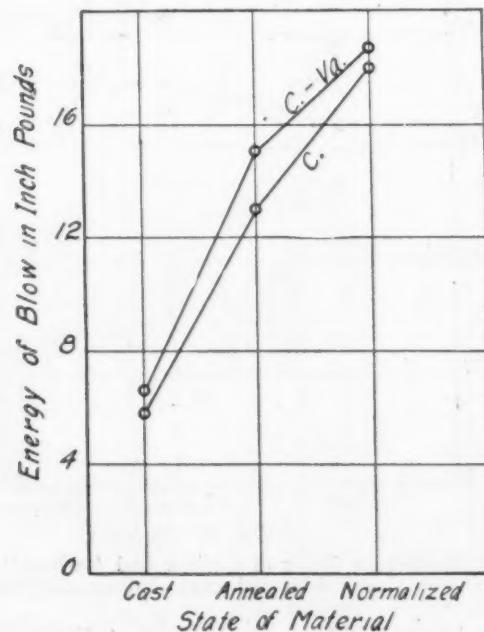


Fig. 6—Single-Blow Shock Tests of Carbon and Carbon-Vanadium Steels in the Cast, Annealed and Normalized Conditions.

## FATIGUE TESTS

The fatigue tests show that the annealed and normalized material is essentially the same for both steels, but that the carbon-vanadium steel has a higher endurance limit than the carbon.\* (Figs. 4 and 7).

In interpreting Fig. 7 it must be clearly understood that there are three sets of curves superimposed on each other and

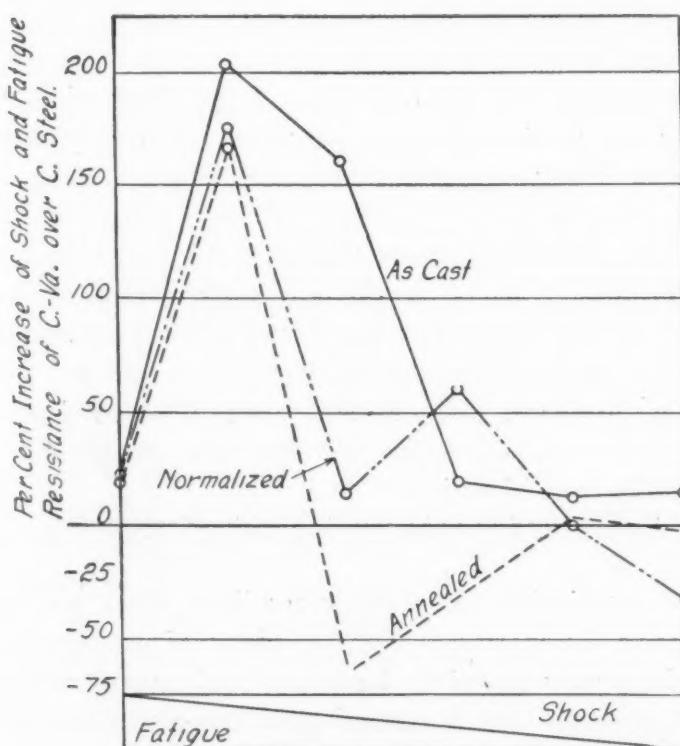


Fig. 7—Increase of Shock and Fatigue Resistance of Carbon-Vanadium Steel over Carbon Steel as Tested in the Cast, Annealed and Normalized Conditions.

that the following comparisons alone can be made.

1. Cast carbon-vanadium steel with cast carbon steel.
2. Annealed carbon-vanadium steel with annealed carbon steel.
3. Normalized carbon-vanadium steel with normalized carbon steel.

The horizontal line through zero represents the carbon material for the three states and the vertical distance from

this line to the particular curve represents the superiority of the vanadium steel. For certain degrees of shock this becomes a negative value, in which case, the carbon steel is the better material.

Fig. 7 cannot be used to compare cast carbon-vanadium steel with annealed carbon steel, such reference must be made to the other figures.

#### CONCLUSIONS

Before attempting to draw conclusions from these results the following points should be noted:

1. These data are the outcome of the first of a series of investigations on steel castings, and were obtained from coupon test pieces cast integrally with a larger casting. Owing to actual cases which have occurred recently, there appears to be some doubt as to the value of coupon test pieces for particular applications, and the publication of results are contemplated in the future which will show that the coupon test is not always representative of the material in the body of the casting.

2. Since, however, these results were obtained from coupon test pieces cast in a similar manner they are comparable for the two steels under consideration.

On this basis the following is indicative: (See Figs. 2, 3, 4, 5, 6, and 7).

a. The superiority of carbon-vanadium steel castings over those of carbon composition (in the class of casting of which the test castings may properly be considered representative).

b. The necessity for normalizing carbon-vanadium steel castings, although this does not appear to be so advantageous for the carbon steel material.

This will indicate how, from considerations of all aspects, the benefits of heat treatment can best be shown and data compiled for the use of the designing engineer. The author is indebted to the Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., in whose research laboratory these tests have been conducted, for permission to publish these results, and to Paul Irwin for the assistance given.

#### Discussion of Mr. Lessells' Paper

A. V. de FOREST: I am very glad, indeed, to see a comparison made of two materials when one of the properties in which we are

interested is made the same for the two materials, that is, a comparison between two materials when their fatigue limits are alike; then in that state comparing shock resistance properties. I think that with comparisons made on the same base line we can get a very much better idea of the suitability of any material than when the shock and fatigue properties are stated, but there is no basis for comparison. We could apply that, I think, in a great many different cases, but none more effectively than in the relationship between shock and fatigue.

I think that is the fundamental question in the usefulness of most of our engineering materials rather than in the question of yield points, and tensile strengths, and elongations.

ACTING-CHAIRMAN DAVIS: I have been rather interested in the showing of the advantage of the normalizing over the annealing treatment when it comes to shock resisting qualities. In a purely practical way, any man who has been in a warehouse and seen steels of various characters—I have in mind more particularly forged and rolled steels—cropped day after day, will know that the normalized steel tends, generally, to be very much tougher and to resist a nick and break test better than the same steel when annealed.

PROF. H. M. BOYLSTON: I did not hear the first part of the paper, and I would like to ask Mr. Lessells if he has defined what he means by normalizing and annealing in this case, because there seem to be differences of opinion as to the definition of normalizing and annealing, and some of the other heat treatments.

ACTING-CHAIRMAN DAVIS: That is a very pertinent question, I would like to have that answered, myself.

J. M. LESSELLS: I will leave that to the metallurgist, but there is in this paper data given on the heat treatments. The annealing operation is defined as that of heating to 925 degrees Cent. (1700 degrees Fahr.) and cooling in the furnace. The normalizing operation is defined as that of heating to 1700 degrees Fahr. and cooling in the air. On this basis the whole paper depends. The normalizing operation is an air cooling, the annealing operation is a furnace cooling, or slow cooling.

D. J. GRANGER: I would like to ask if the normalizing heating operation was held for any specified time?

J. M. LESSELLS: I would refer these remarks to Mr. Merten, who is present and handled the heat treatment. I would rather he would answer these questions.

W. J. MERTEN: The sections, I believe, of the shafting were 4-inch diameter.

J. M. LESSELLS: No, they were rectangular sections of dimensions given in the paper.

W. J. MERTEN: They were held at the temperature of 1700 de-

grees Fahr. for not less than an hour and a quarter. However, on analyzing the result of Mr. Lessells' investigation it occurred to me that probably the coincident fatigue values of annealed and normalized material might be due to a rather peculiar structural character. We had to go to 1700 degrees Fahr. for normalizing in order to break up the ingot structure or cast structure. Cooling from that temperature in air produces internal straining which should have been relieved by a succeeding draw in order to give more favorable results that are indicated in Mr. Lessells' chart.

The annealing operation, followed by a slow cooling in the furnace being conducted at the same temperature of 1700 degrees Fahr., resulted in a partial return to the casting structure. It certainly seems very peculiar that a partial return or reversion to the ingot structure should have resulted in the lowering of values for fatigue resistance of the annealed steel to the same magnitude as the internal straining due to the fast cooling in the normalized steel, and, while I had not time to go into this more directly, I intend to make an analysis of this rather striking phenomenon. It does not seem right that the normalized condition of the steel or the refined structure should have given the same results as the annealed material. Undoubtedly, due to the slow cooling and the return of the structure to the cast condition in the annealed steel, the resistance to dynamic stresses is lower than in a refined, normalized structure.

ACTING-CHAIRMAN DAVIS: Mr. Merten, the temperature reached in each case was substantially the same, the difference being that one was furnace-cooled, and the other air-cooled?

W. J. MERTEN: Yes.

ACTING-CHAIRMAN DAVIS: The annealing temperature, perhaps, maintained somewhat longer before the cooling started in?

W. J. MERTEN: It was.

ACTING-CHAIRMAN DAVIS: It is quite clear that under those conditions we would expect a development of somewhat larger grain growth under annealed conditions, and it would be reasonable to expect that the shock resisting qualities would be somewhat less.

MR. EATON: I understand these test coupons were treated independently from the main casting, that is, they were removed from the body casting and then given heat treatment.

W. J. MERTEN: Yes.

MR. EATON: I wonder if I am not justified in the assumption that the annealed coupon is quite similar in its characteristics to what it would have been had the treatment been prior to the detachment of the coupon, and that the normalized coupon cooled very much more rapidly than it would have had it been attached to the main body. As we are interested in the entire casting, we cannot depend on securing the very fine results shown in the normalized material as well

as we can depend on the results which are shown in these tests on the annealed material. I am talking now entirely from the point of view of the designing engineer, and not that of the metallurgist. I viewed with a great deal of interest Mr. Lessells' comment on the coupon test. I felt he paid his respects to the coupon test with a great deal of Christian charity, and I would like to redraft that paragraph in his paper by stating that in some of my recent experience the coupon test is absolutely misrepresentative and utterly worthless. I do not say always; I say sometimes. I will define the class of casting where this is true, as a casting where the machining operation which is performed upon the casting permits in a deeply imbedded part of the casting a stress which is greater in service than that in any other part of the casting.

As an illustration I will take an obsolete case, a turbo-rotor, 26 inches in diameter, cast steel, running at 3600 revolutions per minute, a casting six or seven feet long, and the practice of some makers was to put an exploration hole through the axis, because they were afraid of a pipe in the casting. When we spin this at 3600 revolutions per minute the stress on the surface of the hole is far in excess of the stress in any other part of the machine. Now what does the coupon test tell us about that material. That material is 12 inches away from any possible coupon, and, to put it in the vernacular, one simply sticks his finger in his eye if he uses the coupon test to tell him what his factor of safety is in the part of the machine where he is most vitally interested, i. e., the part of the machine where failure will occur sooner than any other place.

Gentlemen, we plead for a hollow drill test in classes of castings where it applies. We have many such castings. The coupon test is something, but it is something to tell you what you haven't got. Now we want to know what we have, so that we can tell our factor of safety. I don't know of any place where we can go with a specification for a hollow drill test and receive a guarantee of what we are justified in expecting. We don't expect as good results as we get in the coupon, we want the coupon to tell what the melting practice has been, but we want to know what the steel is after it is heat treated, and in its final condition in the place that is critical. I feel that that is a problem which we are justified in putting up to your society, and asking for the placing of that subject on the agenda of whatever is your proper committee, and beginning to collect experience so that at some time in the future we can have a specification where we are justified in asking the foundry to produce a certain result in the hollow drilled test. Then the designer can go ahead with assurance and build his machines.

J. F. CULP: Several weeks prior to coming to Pittsburgh we submitted for testing, two rotor spiders that weighed approximately 20,000 pounds apiece. We tested the coupons attached to these castings in the presence of the inspectors. The castings failed in some

respects. These castings were normalized carbon steel castings. On account of the rigid specifications we felt that these castings were within the limits, or over the prescribed limits very much. It was suggested that we hollow bore the castings to obtain test specimens. Fortunately, in the molding of these castings some excess metal appeared on the castings, which permitted us to drill these test specimens. The specimens were then tested in the laboratory and showed an increase of approximately 35 per cent over any results we obtained from the test coupons.

I also found this summer in another casting plant where they relied on the coupons and lost approximately 75,000 pounds of castings because the customer would not permit a hollow drill to be used in the castings to get a test.

I feel, not only from the metallurgical standpoint, but from the engineering standpoint, that this procedure should be followed, especially in respect to locomotive frames. I know of one railroad operating in the anthracite region which in testing 29 vanadium engine frames got only one frame to pass on test coupons. These frames, several of them, were taken and cut up and tested and all of them met the specification. The engineer of tests in charge of these tests said that he felt that it would be well to redesign locomotive frames in order that they could get a hollow drill test and thus eliminate the test coupon.

Insofar as our own work is concerned in the locomotive frame business and locomotive parts, we use a test coupon, although when we are making materials for outside plants, we enlarge certain parts of our frames and take our tests out of those enlarged parts, which could be later machined out.

ACTING-CHAIRMAN DAVIS: The point that has been brought out by Mr. Eaton and Mr. Culp is an exceedingly important one. Of course, it goes without saying that any coupon test may be either better or worse, according to what your specifications are, and what you are endeavoring to get. It is a question that should be gone into thoroughly.

J. M. LESSELLS: I have considered the various comments made on my paper and would like to reply as follows. The tempering operation subsequent to normalizing recommended by Mr. Merten would probably not have given the beneficial results suggested by him because no great degree of internal stress was present as will be seen by reference to the tensile test results for that condition. The effect, therefore, of this internal stress on the endurance limit may not be so great as is evident for material other than steel castings.

With reference to the remarks of Mr. Eaton, I may say that there are two things to be determined: First, characteristics of a material; second, physical values for a particular application. The paper deals with the first part and, therefore, the use of the coupon was warranted.

In order to apply this information the designing engineer must know the physical properties of the piece as it goes into service. This can only be determined by tests from the piece itself and data from this in many cases cannot be obtained from a coupon test. I am, therefore, in hearty agreement with Mr. Eaton's remarks and believe that some action on such a question as recommended by him should be considered by this society.

The remarks made by Mr. Culp were very interesting. I am afraid, however, that in general a coupon test is always superior in physical values to the piece from which the coupon was taken. It would be very dangerous to accept such statements as at all general and it would be interesting to know if he would care to accept business on the basis that the results he gives could be generally applied.

## FUNDAMENTALS ESSENTIAL TO IMPROVED QUALITY STEEL PRODUCTION

By Emil Gathmann

### *Abstract*

*This paper sets forth fundamentals essential to high quality steel production and certain improved ingot molds and appliances, whereby tonnage production of sound steel has been made possible and practicable.*

*Prior to the government's insistence upon a literal fulfillment of its exacting specifications for quality in vast tonnage of material, the user of so-called commercial quality mill and forging steel, with few exceptions, accepted (with frequent complaints, it is true) many defects, which were known to be inherent in the usual type of pyramidal, big-end-down ingots.*

*As early as 1912 and 1913, the writer and many other engineers and metallurgists called the attention of steel makers to the fact that an unsound ingot could not by any amount of work, be made into a sound or homogeneous product. Little interest was, however, given by the commercial steel maker to this fundamental requirement of sound ingots, until the ordnance and navy departments, insisted upon their interpretation of the term of "soundness." Today commercial users of quality steel likewise insist upon and obtain real soundness in steel used in their arts.*

*It is the author's confirmed belief, reinforced by the opinions and practice of many leading engineers, metallurgists, and quality steel makers, that one of the fundamentals in commercial quality steel production is the use of the big-end-up or inverted pyramidal ingot, in combination with other fundamental practice as described in detail in this paper.*

### INTRODUCTION

**S**TEEL deoxidized as well as may be, which is or should be the basis of most quality steel products, solidifies by what has been termed by the late Dr. Henry Marion Howe "the pinetree or land-locking type of crystallization," there be-

---

A paper presented before a meeting of the Washington chapter of the Society, December, 1923. The author, Emil Gathmann, is vice president and general manager of the Gathmann Engineering Co., Baltimore, Maryland.

ing no gases evolved due to chemical reaction and a minimum of gases in solution, during solidification of the ingot.

This mass of liquid steel lies quietly upon being teemed in the mold, and crystals form, grow and extend into the mother liquor or molten interior of the ingot, from its initially solidified outer portion or ingot skin, until finally the crystals have formed a solid interlocking mass, thus building the structure of ingots of this type without blow holes; but leaving a void

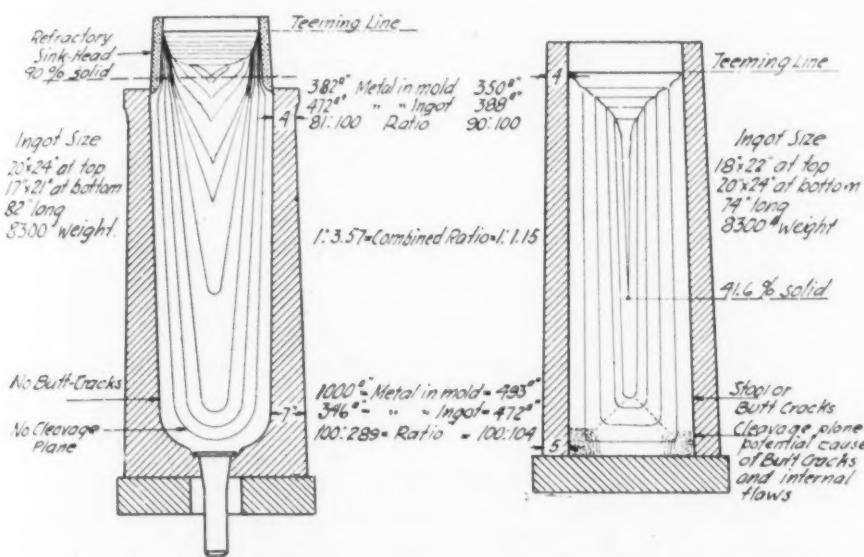


Fig. 1—Diagrammatic sketch showing the freezing and formation of well deoxidized steel when made in big-end-up and big-end-down ingot molds of the same size and cross section.

or so-called pipe, due to volumetric shrinkage, extending downwardly from the upper portion of the ingot. The depth, but not the volume of the pipe or shrinkage cavity depends upon the type of mold and method of teeming and cooling of the ingot.

Fig. 1 is a diagrammatic sketch, showing the freezing or formation of ingots of well-deoxidized steel. The big-end-up and big-end-down molds of the same size and cross section are illustrated, and by means of contour lines, freezing or successive ingot skin thicknesses illustrate the method of solidification and the type of shrinkage cavity produced in the ingots made in these two types of molds.

It is essential, in order to prevent a deep-seated pipe in the solidified ingot, that the growth of the pinetree crystals

should be induced or accelerated from the bottom of the ingot inwardly. This method permits a continuous body of liquid steel to automatically exist to the upper portion of the ingot, and thus reduce the depth of the shrinkage cavity or pipe, due to the decrease in the volume of steel within the original skin or envelope, initially solidified by contact with the walls of the mold cavity. The best and most economic results in the formation of this type of casting are obtained by employing the big-end-up mold, and in so shaping the ingot that it will have a continuously increased volume of horizontal cross section from the bottom of the ingot, upward. The final reservoir of molten steel for feeding the portions of the ingot located below the refractory top portion of the metallic mold, is provided by means of a suitable refractory heat insulating sinkhead as shown.

The diagrammatic structure of the ingot shown in the big-end-up and big-end-down molds has been proven to be correct by many tests conducted at various steel plants, and is today accepted as part of the proven art, by almost all makers and users of quality steel.

In order to obtain an open pipe, i.e., prevent the formation of a frozen ceiling or bridge covering up the sinkhead cavity, it is necessary to cover the entire top of the molten steel immediately after the ingot is poured, with a material of high heat-insulating quality, such as infusorial earth, flake graphite, or similar substances. The pipe or shrinkage cavity will then remain entirely open and the entire process of the formation of the pipe may be readily observed.

In actual commercial practice, it is not recommended that a pipe of this character be produced, as it is preferable to allow the top of the ingot to solidify before placing any heat-insulating medium thereon.

Graphite or any other carbonaceous material naturally should not be employed as a top covering for any ingot, excepting for experimental purposes to demonstrate the formation of pipes in thoroughly deoxidized steel.

Excessive taper of an ingot is usually objectionable, both for mill and forge practice. It has been found that a considerable decrease in taper is permissible without changing the

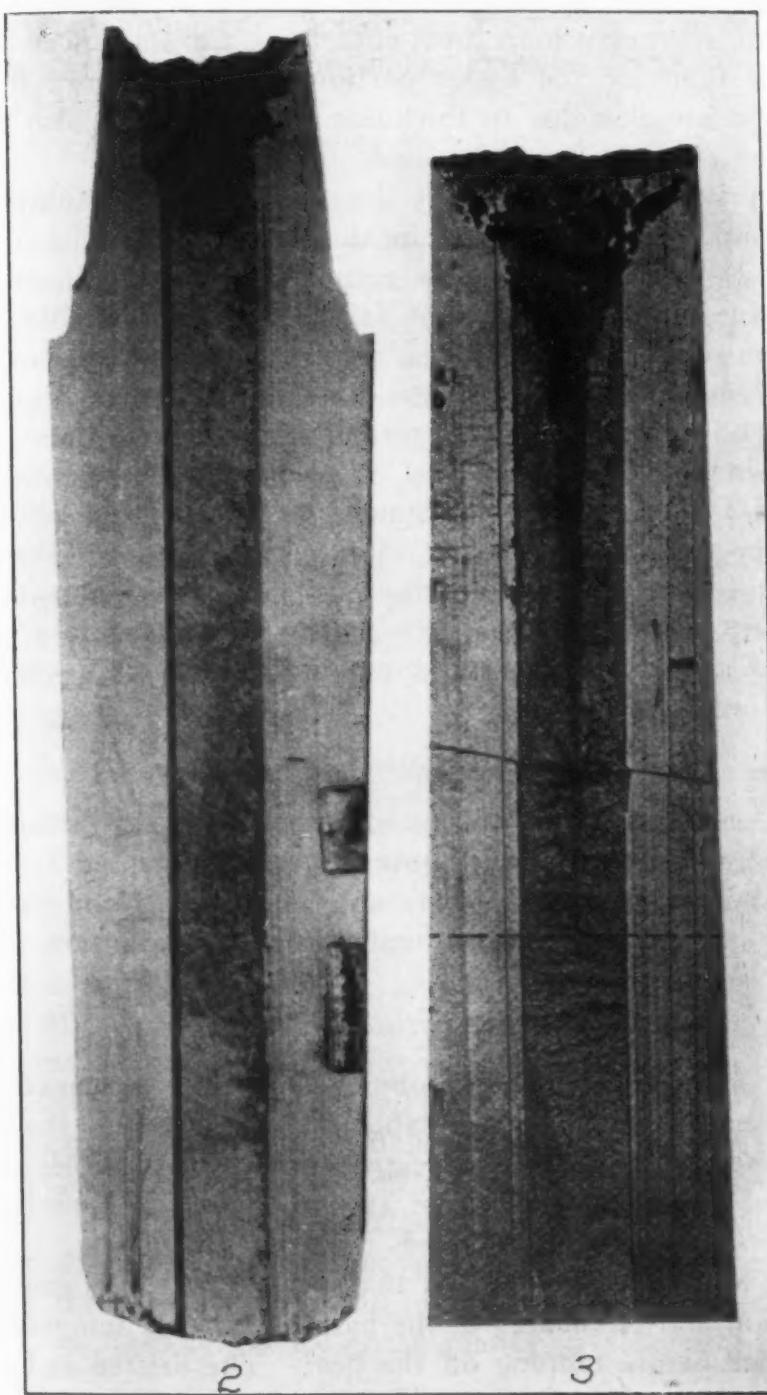


Fig. 2—Photograph showing a large split ingot made in a big-end-up mold with a re-reactory top. Fig. 3—Photograph of a standard big-end-down ingot mold without the use of a sink head. This ingot is similar in size to that in Fig. 2. Ingot in Fig. 3 produced 41.6 per cent sound metal and a discard of 58.4 per cent.

character of the shrinkage cavity desired, if the mold walls are made relatively more heat-absorptive for the lower section of ingot than for the upper portion. The difference in ratio of heat absorption due to thickness of mold walls, also due to increased areas of ingot, is shown on Fig. 1.

The shrinkage cavities in the standard big-end-down and big-end-up ingots as shown in this chart are a fair average from many tests made. The actual lines of solidification as shown are taken from data as far as such is available in the literature of the art, as well as from the writer's experimental data. Some lines for which experimental data has been lacking, have been placed by interpolation between lines which have been arrived at by actual experiment.

Fig. 2 shows a large ingot made in a big-end-up mold with refractory top and a layer of graphite top insulation placed on the liquid steel. This photograph of an ingot illustrates the big-end-up type of ingot shown in Fig. 1. Fig. 3 is a photograph of a standard big-end-down ingot, without a sinkhead, but of similar body size.

#### THE FUNDAMENTALS

In the making of sound quality steel there are certain fundamental requirements which are generally accepted by those steel makers who are at the present time leading and showing the way to further improvements, in the production of the product.

#### PREPARATION OF THE MOLTEN METAL

The first requirement is obviously in the preparation of the molten metal. It is advisable that the steel in the bath, be it Bessemer, open hearth, electric furnace or crucible, should be melted from stock with the assurance that a minimum of deleterious matter be introduced.

The second requirement is that proper finishing (meaning deoxidation and cleansing) of the bath at suitable temperatures be obtained before tapping off the heat. The degree and character of finishing and deoxidation is dependent upon the character, grade and quality of the final product required.

The third requirement is that some deoxidation or finishing in the ladle is essential, especially for the higher grades

and qualities of steel, but this finishing in the ladle should be held to a minimum and should be confined to such as cannot be done previously without undue expense or administrative difficulties.

#### TEEMING OF THE MOLDS

There is always a certain volumetric shrinkage of steel of any specification in going from the molten state to the solid, and is dependent on the factors of temperature of the molten metal, chemical composition of the metal and the volume of gases present in it at the time of teeming, i.e., the hotter the molten metal, the greater the difference in the reduction of volume to the solid state. It is advisable that the pouring temperature or that at which the steel is teemed into the molds, should be no higher for top casting than necessary to obtain a clean teeming stream. To regulate the time of pouring, a suitable size of ladle nozzle should be used, the specific cross section of the nozzle varying with the character, grade and quality of steel, and with the cross section and weight of the ingot being teemed.

#### SOLIDIFICATION OF THE MOLTEN STEEL IN THE MOLD

The ingot solidifies in the mold by crystallization, which starts at right angles to the ingot's exterior surface, both sides and bottom. If this surface is in contact with the mold chamber walls of a plain rectangular contour, either at the base or the sides, it follows that the axes of dendritic crystallization are mostly parallel lines resulting in the formation, (where these axes intersect due to corners) of cleavage planes injurious to the strength of the ingot. These cleavage planes are more pronounced in well-deoxidized ingots than in ingots produced from a gassy or boiling molten metal. It has long been well-known that if the vertical surface of the ingot is suitably corrugated or fluted, or of a polygon cross section, the axes of crystallization are crossed and interwoven and hence eliminate, or at least greatly reduce these planes of cleavage, and thus give a stronger ingot structure.

#### CONTACT OF INGOT WITH MOLD WALLS

The ingot should be free at all times to shrink during

solidification and formation of the ingot structure in any and all directions within the mold chamber and consequently the chamber should be so designed as to prevent any mechanical binding or tying of the ingot, to the mold walls. The contour of the mold chamber, both vertically and horizontally, should thus be so shaped as to allow for free and unimpeded shrinkage of the ingot and the walls should be clean and free of foreign matter.

As the ingot solidifies progressively, from its outer portion initially in contact with the mold chamber walls, the walls should be so constructed that they will firmly support this outer solidified surface of the ingot for a brief period of time, or until the initial walls or skin has become sufficiently thick and firm to resist liquid pressure of the molten mass, forming the interior of the ingot. The mold walls should, therefore, be relatively heavy as compared to the section of the ingot.

The greater heat absorptive value of heavy, as compared with light mold walls, favors the important time factor of rate of solidification. The shorter the time of solidification, the greater will be the number of independent nuclei from which solidification proceeds, which leads to an increase in the number, and the rapidity of the growth of smaller forms of dendrites extending inwardly from the molded surface, or skin of the ingot. This increase in the number, and decrease in the size of the dendrites and their rapidity of growth, is most important, as it prevents, or at least greatly reduces, coarse crystallization and columnar forms of the outer parts of the ingot, thus building a more homogeneous and stronger ingot structure.

#### STRIPPING AND REHEATING OF THE INGOT

The sound steel ingot should not be stripped from the mold, or the mold from the ingot, until the ingot has become substantially solidified throughout its entire volume. In high carbon and alloy steels this time interval is considerably greater than in low carbon or open steel.

The ingot should be charged hot in the soaking pit or reheating furnace, as soon as practicable after stripping from the mold, and allowed to soak or equalize in temperature, before reheating to a suitable rolling or forging temperature.

### REDUCTION OF THE INGOT

It should always be remembered that the ingot, irrespective of its physical or chemical analysis, when taken from the soaking pit or heating furnace, is merely a heated steel casting (a chilled casting) and until work is done upon its surfaces, has inevitably the weakness inherent in castings, as compared with forgings. The work, therefore, must be so done that no unworked surface receives appreciable deformation before the ingot itself is worked. In practice in rolling mills, this is accomplished by making the initial passes light, and frequently turning the ingot, the extent to which this law can be followed being governed by business considerations.

### THE BIG-END-UP MOLD

Fig. 4 shows the design of a typical big-end-up type of ingot mold for floor or pit practice. This type of mold is in extensive use in production of ingots having a cross section of from 6 x 6 inches to 16 x 16 inches and weighs from 350 pounds to 3600 pounds per ingot.

This ingot mold has a cavity 7 inches square at its lower end and 9 inches square at the upper end; also the lower mold wall is  $4\frac{3}{4}$  inches thick, while at its upper end it is only  $2\frac{1}{2}$  inches thick. These ingot dimensions and mold wall thicknesses, give a freezing ratio for this mold of approximately 6 to 1, or in other words, the mold per cubic inch of ingot considered, absorbs heat six times more rapidly at its lower end, than at its upper end, with intermediate values of heat absorption between these points. This large freezing ratio is necessary for ingots with a high ratio of length to diameter. The lower end of the ingot is necked in and formed by a compound curve ending in a flat bottom or plate recess, thus effectively preventing cleavage cones and butt cracks.

The bottom of the mold is closed by a conical closing and stripping plug, the lower portion of which projects below the mold bottom to be used as an ingot ejector when necessary. Above the plug, and fitting closely in the chamber bottom, a plate recess is provided, the function of which is to protect the bottom of the mold chamber against erosive wear and pre-

vent the sticking of the plug to the ingot, the plate itself welds fast to the bottom of the ingot and is cropped therewith.

The sinkhead or refractory top shown, is designed to be placed on the molten steel as soon as the mold is filled to its desired height, and then itself poured full. This method of

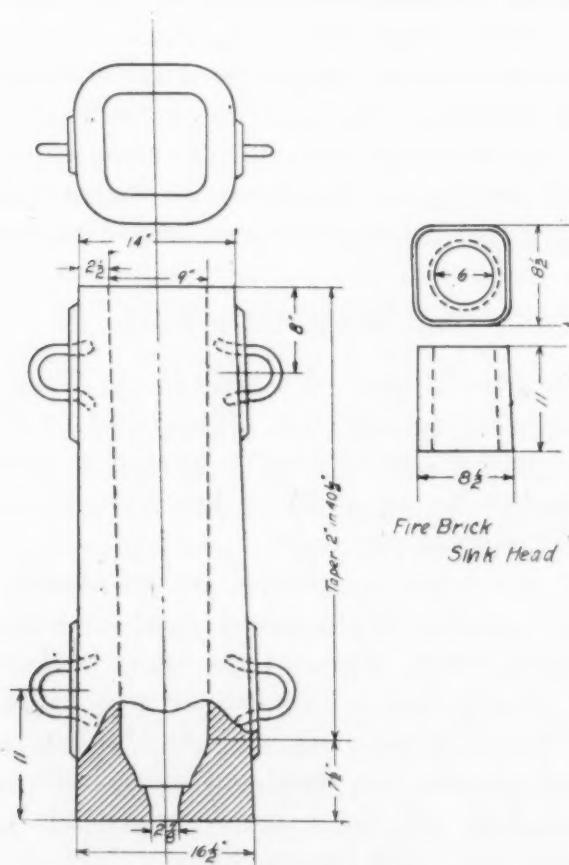


Fig. 4—Typical Big-End-Up Type of Mold for Floor or Pit Practice

hot-topping is the standard old nozzle practice of crucible steel makers, the advantage of this type of hot top being, that part of the shrinkage of the ingot takes place before the sinkhead is filled.

It is difficult in large ingots to perform the timing operation correctly and in these a sinkhead is placed on top of the mold, through which the steel is poured for the entire ingot. The hot-top for all molds should be so constructed or equipped,

that hanging of the ingot in the top will not occur, as this hanging is apt to impede free shrinkage of the solidifying ingot structure.

In stripping, the ingot may be either caught by its sink-head with suitable tongs and lifted out, or the mold may be upset and the ingot dumped, whichever method is most suitable to the individual plant.

The yield of sound steel obtainable from ingots of this type and size, is dependent mainly on the segregation range permissible within the ingot, and the workmanship or skill with which the various operations are carried out.

For ingots from 6 inches square to 12 inches square there is little carbon segregation, the solidification taking place so rapidly that the dendrites entangle the segregates before they have a chance to emigrate and cool in clots. This yield in actual practice is somewhere between 85 and 90 per cent of the ingot weight for the sizes of ingots mentioned. For larger ingots up to 34 inches square, weighing 20,000 pounds, the yields are dependent on these same factors, in addition to which the type and heat efficiency of the sinkhead largely enter. The yields obtainable here, range from 80 to 85 per cent of the ingot weight, being less as the size and weight of the ingot increases.

The desirability of all products being made as sound as the state of the art permits, is unquestionable. There are, however, many practicable and commercial problems involved in tonnage steel production, and at the present state of the art, it costs the steel maker from three to ten dollars additional per ton of product to produce reliable, homogeneous steel in the bloom, billet or bar, without, however, necessitating any reduction in the tonnage output.

The insuring of better surface conditions of the steel ingot and its products, by employing molds of suitable chamber contour, does not, however, involve any added expense in either high grade or so-called commercial tonnage specifications.

It is the writer's opinion that we are just at the beginning of our knowledge of this most important art. The aim of this

paper is to bring on a full discussion of all points involved, in the hope that from this exchange of ideas, new knowledge may be made available to those whose work it is to apply these principles to industry. In this manner they may be better able to produce steels more economically and which are more reliable, under the severe tests to which they may be and in some cases must be put by their users.

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SYMPORIUM ON METALLURGICAL EDUCATION  
HELD AT THE FIFTH ANNUAL CONVENTION OF  
THE SOCIETY, PITTSBURGH, OCTOBER, 1923

**I**N OPENING this session, the chairman, Prof. S. L. Goodale, University of Pittsburgh, commented as follows:

"By way of introduction in opening this session, which is really a continuation of the discussion held in Detroit, a year ago, I wish to present briefly some of my views on this subject. Then we shall call upon the men who have prepared formal papers. The subject will then be open for general discussion.

"It seems to me that special metallurgical education is, or should be, something of a compromise. We find some men going into metallurgical work from a mechanical engineering training, some from a chemical engineering training and still others from electrical engineering training; and in addition to all of these, we have a course of special training for men who plan definitely to get into metallurgical work. And any man so trained must be able to compete to advantage with the men who have received more specialized training, mechanical, chemical or electrical.

"Very few students know, while in the engineering school, just what line of practice they will go into. We must, therefore, prepare our students so that they can take positions in any one of several different branches of metallurgy and handle the work with reasonable facility. For instance, they may take up any one or more of such varied lines as the blast furnace, the open-hearth, the electric furnace, or even ore dressing; the shaping of metals, rolling, pressing, hammering; determining the composition of alloys, or determining the heat treatment thereof. We find also that a good many of our graduates, after being in metallurgical work for a while, work into managerial positions or go into the selling field. This condition or situation brings up the point that these men should be given more preparation in the study of economics, salesmanship, business administration, business law, etc. We are meeting this demand as well as we can meet it within the time limit.

"It is difficult to arrange a course which shall fit a man for any one of the fields of work he gets into. These varied requirements have led us more and more to generalize our course. Primarily, we try to emphasize the fundamentals of the sciences, and their relationships, and the methods of application of these fundamental

principles, and the manner in which these fundamental principles are applied in engineering. If each student can really get a proper grasp of the basic principles, and a brief study of some typical applications of certain facts and theories of physics and chemistry, his four-year training will probably have been worth all it cost him.

"When I joined the faculty of the University of Pittsburgh in 1909, we had a very peculiar type of course in the school of mines. There was listed in the department of metallurgy something over 120 different detailed courses in metallurgy in addition to a similar number in ore dressing. Fortunately I was called upon to teach only a comparatively few of these courses. At that time we started specializing the men in metallurgy, or in mining, in their sophomore or even in their freshman year.

"As a side issue I wish to say that there was really a splendid idea back of the listing of so many courses at the University of Pittsburgh. It was that the university should give opportunity for extremely specialized work in each field. It was believed that at least at some one place in this country, it ought to be possible to do this, under university auspices, and with good guidance for the students. Financial support for educational institutions has so far been too limited to make the realization of that ideal possible in our universities. Under much different detail of management and of result, however, about the same thing is really being accomplished by many commercial concerns, and by the bureau of mines and the bureau of standards, and other organizations in their research work. This development is commented upon with great regret by some prominent educators, in their belief that "business has taken research out of the universities." Research has not been abandoned in the universities; but, in many cases, it is carried on only under great handicaps.

"At the present time we are going so far in the other direction of generalizing our courses, and emphasizing fundamental training rather than specialties, that we are giving the boys two years of "Arts" training before they come into contact with their technical work. In the junior and senior years, we are emphasizing the fundamental sciences more than we have done before, and are giving the men more time in physics and chemistry, and more time in applications of the sciences. Less time is devoted to the

specialties, such as the blast furnace, the open hearth, etc., although we do give them some intensive work along those important lines. If a man wants to study in some special field at greater length, he can take an extra year or so, and work for a higher degree."

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## A CONTRIBUTION TO THE SYMPOSIUM ON METALLURGICAL EDUCATION

By C. Upthegrove<sup>1</sup>

RESUMABLY this symposium has for its purpose a discussion of the curriculum for metallurgical education with a view of aiding thereby in the advancement of metallurgical education. In order that the best results may be attained from such a discussion it would seem that numerous questions would first have to be answered, particularly as to what constitutes the aim or purpose of a metallurgical education.

Will metallurgical education of the future have the same purpose or may we expect a change, and if so, in what direction? Again if we are to bring about changes in our plan of metallurgical training, what means, or what methods shall we use for determining or evaluating the results obtained from such changes? These are the points I think we will have to consider rather carefully in order to arrive at any definite results.

Our first consideration in the discussion of the curriculum for metallurgical education should be to ask whether or not our present metallurgical training actually fits the graduate to do the work that is expected of him. Does the present type of education so train the graduate that he is able to make the best of his opportunities, or—this may be putting it a little strongly—does metallurgical education by the very nature of its present curriculum possibly prevent him from entering desirable and proper fields of endeavor? If we may judge from the fact that our graduates are taken into the industries every year and apparently do make good, then it must be that they leave the university, or the college, with sufficient technical training to enable them to do the work that is expected of them, and to grow in experience with increasing ex-

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1. The author is professor of metallurgy, University of Michigan, Ann Arbor, Michigan.

actness in their duties. Yet we are continually reminded by executives and the professional engineers that engineering training has become too highly specialized, and in some cases to the detriment of a training in the fundamentals. Early specialization and a tendency to take courses which will have immediate application in the way of an earning capacity are deprecated. A plea is made for a more liberal foundation for engineering training, for a broader training in the fundamentals.

As to whether or not the present training limits the opportunities, or fields of endeavor, for the engineering graduate, we have only to turn for our answer, to the insistent demand for courses which deal with, rather than eliminate, the human element. Under the present plan of engineering education it is extremely doubtful—I think most of us will agree in this—that the engineering graduate is trained along lines which enables him to make the most or the best use of his opportunities. With our rapidly changing civilization and its increasing complexities, the graduate engineer must continually find himself facing problems that are going to deal with fields entirely outside of his technical knowledge. To obtain a solution he must turn to other fields such as economics, administration, accounting, law and possibly history. Many other subjects have been suggested as offering a background for the engineer in meeting problems of this type.

While I have been speaking of engineering education in general, what I have said is equally true of metallurgical education. It is evident, at the best, that only a few of the courses now suggested as additions to our engineering curricula, by various men and organizations that have made a fairly thorough study of our engineering education, could be introduced into the present course without the elimination of what is considered essential engineering matter, or without the lengthening of our course. A five year course would undoubtedly offer many advantages. However, I believe that it would be a serious mistake to lengthen our course at the present time, at least. The present plan that most of the institutions have, of a four year course with an optional fifth year, it seems to me is much more desirable, and I believe we must come to the understanding that the five-year course is really not the course for all the men who enter an engineering school.

Rather than lengthen the course in order to meet this demand

for introduction of additional subjects—and the appearance of economics in many of our curricula indicates that we are not unresponsive to this demand—might it not be better to eliminate from the present course of study, certain courses which in themselves may be decidedly worth while, but which have largely lost their value to the metallurgical engineer? In outlining a course in metallurgical education it seems to me provision should first be made for the broadest possible training in chemistry, mathematics and physics. There are certain other subjects that we might list as being fundamentals, but if we base our training upon chemistry, mathematics and physics we will have really a good foundation to begin with.

A thorough training in mathematics need not, however, include differential equations. I believe for the metallurgical engineer who is taking the four year course we might very well stop with calculus. The work in differential equations may well be left for the man who is going to take the five year course, or who even goes farther and takes his doctor's degree. Some engineers even go so far as to say that we might dispense with calculus. My own opinion, however, would favor the retention of the calculus to the extent it is given at present.

Chemistry should include inorganic chemistry, a limited amount of analytic chemistry, and a course, or courses, in physical chemistry. Too much emphasis cannot be placed upon the value to the metallurgical engineer of a thorough understanding and an ability to apply the principles of physical chemistry. I feel that this is one of the things which has been rather neglected in the fundamental training of our metallurgists.

I am going to mention a few other subjects which I think may bring up points of interest in connection with the idea of the four year curriculum. Modern languages should be included in the curriculum, though many professional engineers are inclined to doubt their value. It is believed, though, that the time now devoted to languages in most engineering schools might well be reduced. As it is now taught primarily to give the student a reading knowledge, it would seem that a shorter course should produce the desired results. Application, or use, of this reading knowledge during the junior and senior years would be decidedly more to the point. Unfortunately, in some of our engineering

schools at the present time the student is given two years of training in language in addition to what he may have had in high school, and then the opportunity to use it is not given to him until after he leaves the university. Courses in English have an unquestioned place in any curriculum. There may be some question as to the type of course, and particularly as to the value of some of the various modifications such as commercial English, business English and so on. The question might be raised here, would it not be better to confine the teaching of English to literary English.

The value of some of the mining engineering courses now found in part of the metallurgical curricula may well be questioned. Assaying carries little of value for the present day metallurgical engineer. Similarly surveying be it mining or otherwise, it is believed may well be dropped from the course of study.

The introduction of courses in economics and accounting is particularly desirable. The demand for the first is being met to a certain degree by most of our engineering schools. Instruction in accounting, however, is limited in the most part to the man taking the five year course. In the past, engineering schools seemed to have paid little attention to the requisites which provide for financial success for engineers. Maybe we should not look on it in quite that way, but in some ways it hardly seems fair that we should not take into account that side of his training.

The course in history was mentioned. Just what course would be the proper course to be introduced in the metallurgical training I do not know. It would seem, though, that any course which had to do with principles and developments rather than with facts and dates might prove of considerable value in the training of any engineering graduate, whether he turned out to be metallurgical, mechanical, or some other type of engineer. That is particularly true if we expect that the engineer is gradually going to move more and more into public life. The fact that we now have quite a few prominent engineering men in high positions in this country seems to indicate a definite tendency on the part of the public to demand that the engineer enter into that type of work.

In regard to technical instruction it is believed that the metallurgical engineer could very well afford to devote more time to

the fundamentals of other types of engineering, particularly, I believe, mechanical and electrical engineering. The development in electro-metallurgy of the last few years makes the need for the latter almost imperative.

In closing it must be pointed out that whatever we may include in the curriculum, or whatever the nature of the training may be, we must have in mind one definite purpose, that of enabling the student to see clearly and think clearly.

CHAIRMAN S. L. GOODALE: Professor Upthegrove's paper is before you for discussion.

PROF. D. J. DEMOREST: I agree quite generally with what has been said by the last speaker and by the chairman. There are a few things I think which might be worth pointing out, some of general nature and some of more specific nature.

About the modern languages, we have come to the conclusion at Ohio State university that unless we give a man a lot of language the time is wasted, that is, one year or two years, say, of German to the ordinary engineering student leaves him with a lot of time having been spent but without much ability to handle the language. If he starts in on a modern language in the university he really ought to take it through his entire course, say at least three years, because they do not get a reading ability otherwise. That is the chief difficulty with the language situation as we have sized it up. I would very much deplore, as the last speaker has also stated, to see calculus cut down too much. I am convinced, on the other hand, that calculus as it has been taught traditionally as just a mathematics course in a mathematics department, is handled in a way that wastes a good deal of time. A calculus teacher who is thoroughly imbued with the fact that he has some young men before him to whom he must get the conception of calculus rather than just the manipulation to solve some problems that are given out during the course, then you have a man who in half the usual time will impart into the minds of engineering students, a workable knowledge of calculus, so that they can connect the ordinary calculus operations with some kind of visualized thing; it becomes a reality.

We have a professor in Ohio State university, Professor Coddington, who is making a tremendous effort along that line to see that everything that is mentioned in the course of calculus is connected up with some real entity in the man's mind, so it is not merely formulated on paper. If that is accomplished, calculus becomes a real living thing, and the men can use it. If it is not accomplished it is time lost, at least it is time lost to many of the students. I believe that the weakest part of our usual courses in metallurgy is the small amount of physics which we teach, and I believe that we should increase the amount of physics which is given. Of course, the difficulty is much the same as with mathematics, that is the physics departments want to teach our engineering students physics just

like physics is taught to the person who is going to become a business man, or something like that, and much time is wasted.

I disagree with the statement or the opinion expressed, that assaying is not time well spent, because assaying is a magnificent chance to teach the principles of slag formation, and that is the way it is used by us; and not so much merely as a matter of finding how much gold, silver, or platinum the ores or alloys may contain. It is used primarily for teaching the physical chemistry of slag formation, and incidentally quantitative work in the assaying.

PROF. C. UPTHEGROVE: As it is taught now you might well change the name of the course.

PROF. D. J. DEMOREST: The two upper years in metallurgical engineering at Ohio State is really made a reversal of procedure from the two lower years. In the traditional methods of teaching the fundamentals, physics, chemistry and mathematics, the tendency is to go from the abstract to the concrete. Certain laws are brought out and then laboratory experiments are supplemented to make the laws a little clearer, and certain applications in a very elementary sort of way are pointed out.

In our junior and senior years in metallurgy we are taking up in the appropriate places, courses in industry. For instance in our course in fuel, we have started in with a description and operation of the gas producer, and a water gas generator, and the coke ovens, until the student has those things pretty well pictured in his mind, and then we commence asking why is this type of construction used, and why is this operation carried out as it is, and then we get the discussion of "Whys." That brings out the general principles. In other words, in the junior and senior years we take up the things as nearly as we can as they are in industry, so the student has an incentive, and feels that he is getting hold of something real. We then go back and inquire into the principles which underly these operations and then go to the laboratory to prove them. Even in heat treatment and metallurgy we use that procedure largely, take up the various heat treating establishments as typical ones and study them, and inquire into the reason for this kind of quenching, and that kind of drawing, and bring out then the principles involved. We again go to the laboratory and actually carry out those operations to prove the principles are true. I find that it is so much easier to maintain an active interest and a feeling of reality with the student by that reversed procedure.

We are all confronted with the problem of a training in economics and administration, which colleges of commerce of administration are calling management, and we are up against that pretty hard. I have about come to the conclusion that one of the things we must do is to see that, commencing with the junior year, the students get into their libraries certain books on subjects which it is impossible to teach in the four years. Of course, in going through these industries, as was just mentioned, one of the things we inquire about is, "Why is the industry organized as it is?", and that brings out the factors of raw material, market, labor supply, and such things.

But even though we look at the things we teach from really the engineer-

ing point of view, not merely the scientific point of view, and if we point out as we go along the economics involved, that is a very thin veneer of economics that the student gets in that way, and I think we are coming to the necessity of making sure that the student has in his library certain literature on economic and business subjects, and human engineering, and then if the student is the kind of student that is going to make a good engineer he will make some use of them, if he is not I don't see how we can help him much in the four years. I am not in favor of the five year course. It would be just as wrong to insist on a five year course for all engineers as it is to insist that all people who get through the eighth grade should go ahead and go through high school. A great many of them are not made for it, and I think it is quite true that the students who feel the need of the fifth year will come back and get it.

PROF. D. F. McFARLAND: (Pennsylvania State college) In the first place I want to second what Professor Demorest has said about assaying. For a long time I have taught assaying, not as assaying, but as a course in metallurgical principles. While I was at Illinois I called the course Metallurgical Laboratory and Assaying. While we went through the operations of assaying, I frankly stated to the students at the very first that, "probably most of you men will never have occasion to make a fire assay, but I do not know of any way in which you can learn the principles of slag formation and of smelting processes any better than by the procedures of fire assaying. I do not know of any course in which you can find more opportunity to apply the principles of physical chemistry than you can in fire assaying," and I may say that I have never found any course in which the men were more interested and more ready to apply principles, and hunt for principles, than in that course.

There has been a good deal of attack on the retention of assaying in metallurgical courses, and I refer particularly to the articles in *Chemical and Metallurgical Engineering*, but I contend that as we have taught assaying and as we are now teaching it, it is not only a very proper subject to be in the course, but a very necessary one. In our revisions of the course in metallurgical engineering at Pennsylvania State college we have followed, mainly, lines that have been brought out in the address just preceding. The amount and quality of chemistry has been improved, adding more to physical chemistry, as we firmly believe that wherever there is a theory of metallurgy there is applied physical chemistry. And in the matter of mathematics we are cutting down just a little bit, although not very much.

In the matter of language we are also cutting down, but not very much. I do not believe that an engineer of any kind can afford to be without some training in modern languages.

One other principle has governed us in our revision of courses, and that is cutting down the number of subjects taught, and the number of hours taught, and concentrating on those, which we feel are of greatest importance.

Too much spreading of endeavor is not desirable, as the man who has fewer things to concentrate on will do a very much better job than he

would if he had to expand his efforts. We have reduced our course, from 21 or 22 hours to 18 hours, and I think we have very much improved it that way. We have raised the credit hour to a three hour basis so that there is practically as much work involved in the reduced number of credit hours as there was in the larger number, at a smaller value of credit hour. We have eliminated surveying, and training in structures, and have eliminated all but one course in mining engineering. I heartily approve of most of the suggestions that have already been made.

PROF. C. UPTHEGROVE: I should say that Professor McFarland has agreed in regard to the assaying, as has also Professor Demorest. In reality you might say you are giving a course in metallurgical laboratory and have done away entirely with the idea of routine work.

PROF. D. F. McFARLAND: No, we are teaching the men how to make a good assay while we are doing it.

PROF. C. UPTHEGROVE: I will have to accept it that way, I guess.

CHAIRMAN GOODALE: Mr. Crockett of the Jones & Laughlin Steel Corp., has kindly consented to give us something along the line of the work he is doing in preparing their men, especially for sales, along metallurgical lines.

## A CONTRIBUTION TO THE SYMPOSIUM ON METALLURGICAL EDUCATION

By A. E. Crockett

WHEN I come in contact with you gentlemen and realize the efforts that you are putting forth in the training of technical men I hesitate to add anything to what you might suggest, but I am continually receiving your finished product, and you may be interested in hearing how they are progressing. Men come into the bureau of instruction of the Jones & Laughlin Steel Corporation, to have revealed to them several things, the greatest, of course, being the actual process of the manufacture of steel. This involves every operation occurring in this metallurgical process from the iron ore, coal and limestone, on through the blast furnace, coke ovens, steel works, rolling mills and finishing departments. It is not a distant view, but a close contact with every operation, and under the direction of men who are giving their whole time and thought to the particular process under consideration. After five weeks of strenuous study, each man hands in a thesis.

I have been keeping a very close check on the theses, because they present the state of mind of the student. One

thing I have found in going over these and which has been emphasized here, is that there is a lack of thoroughness in English; therefore, one of the things I am going to plead for this afternoon is that you, who will have the young men coming to you, will do everything you can to strengthen their English, and their methods of expression, whether it be in the written or spoken form.

Recently I reviewed a large amount of correspondence, some received from engineers, or those dealing with engineering problems; and too often there was found a lack of good English and clearness in the very thing the writer was endeavoring to convey. While doing this review work, a thought, or picture, kept recurring, and as it related to my own experience, I feel free in telling the incident which dates back to the time when I was in grade school. We had an old teacher who one day demanded that I stay in at recess. Some of you can think back and realize what my feelings were: What have you been doing? what mischief have you been up to? into whom have you been sticking a pin? or, whose window have you broken? During recess, the teacher brought down with the old one arm—which was all he had—his chair, and sitting beside me said: "Master Crockett, you are not catching your mathematics in the right light. I want to impress on you one thing and it will follow you all through your life—that is, that everything has a starting point, and that value I am going to call 'One.' You can split 'One' into as many pieces as you want to, or you can multiply it as many times as it is desirable." Gentlemen, this thought has never left me, and its value has ever increased.

That day one other vital thought was impressed upon me: that was, that "One" always relates to something definite. I find many of those with whom I come in contact have not been as fortunate as I, or have forgotten the kind advice of a loyal friend and instructor, as many of the young men—some of them in the fifties—never sense the direct relationship of figures to a definite object. A quart means nothing to them but, simply a figure. They cannot see a pint or a gill in the subdivision of a given substance. The student must sense, and we in our teaching must bring out, a definite relationship

between a figure and a given object. It is an absolute necessity.

An instance of a lack of relationship and its influence, will probably make clear my point: In May of this year a young man called at my home to discuss some of his educational problems. He stood to flunk and be held back from his possible graduation because his examination in thermodynamics showed that he was deficient in that subject. I encouraged him to tell all his troubles, and finally said: "Hold on, my boy, now let's get down to something definite. You apparently have not analyzed in your mind the relationship between the examples you are working, or the terms that you are working with, to a direct object." Then I proceeded with my first mental picture and told him: "I want to take you to an open-hearth furnace, and you are to charge into that furnace, steel scrap. Do you know what an open-hearth furnace is; do you know what it looks like?"

Fortunately, I had a number of views at home and, as I presented them, he said: "I have seen one; I have been with a class. We were at Bethlehem, and we looked at an open-hearth furnace; but I didn't see anything more than a shell and some heat."

Then it was that I pointed out to him that every bit of gas that was being charged into that furnace, every cubic foot of it, had so many thermal units, expressed as so many B.t.u.'s and that each one of these B.t.u.'s had a direct relationship to the elements present in the gas and the oxygen being drawn into the furnace; that their frictional association created heat and produced an expansion in the furnace.

Then I presented it in somewhat different terms, telling him that the atomic mass that was present in that furnace would change the temperature of the furnace from zero, or from atmosphere to its required heat of around 3000 degrees Fahr. Further, it depended upon the amount of gas you put in there, as to how well you melted your materials charged.

I went through several illustrations of that character, as I was convinced that he had been studying everything simply as so many figures, and not in relation to anything. When I finished with him he grabbed his hat, walked out of the house, and said: "I have been a d—— fool." He never said: "Thank

you, I see it; much obliged." Simply walked away. About two hours later he called me up and said: "Why, I want to apologize for my rudeness in leaving your home as I did, without thanking you."

About three weeks afterward I received a telegram from him: "Passed—100 per cent." Such instances as this lead me to make a strong plea that we relate things in our teaching to something definite; something that a man is going to come in contact with as he goes out in life.

While this symposium will deal with the university training, your influence is far broader, it reaches both backward and forward, and therefore, I am constrained to recite one other experience: It relates to a young woman who last year was finishing her course in college. In her final semester she taught in one of the high schools in central Pennsylvania. I have a letter from the superintendent of that school, and he said this: "I don't know what happened to that teacher, but I do know that the class (it was the Sophomore class) made more progress than at any time up to that moment;" the whole thing is, all her work was related to something definite.

For a few moments I should like to revert to the question of teaching English. I would rather sacrifice in our engineering courses some modern language, because in the average courses we teach in the colleges the student comes out with a smattering of several languages, not qualified to properly express himself in commercial life; consequently it would be far better that he be the master of his own language, and, therefore, able to convey in proper form and expression the facts and information he will, sooner or later, have to convey. This relates to all branches of engineering endeavor. It may be the metallurgist in the mill: he will have to convince his superior of some vital fact; from him he will at times be sent to those higher up; then it is, if he can stand and deliver in good language and elucidate his subject in a clear and concise manner, that this young man is going to do this part of his work successfully.

It is the expectation of all the young men who come under your guidance that they will take their respective places in

life's activities, and on your part you are all training men to advance in life, to take up the broad phases of life, after they have left your direct training. The successful man will be the one best equipped for every endeavor, but the man who can both write well and talk well in good plain English will stand the greatest chance of early being recognized.

Some one said in the beginning of the meeting, that the engineer is coming up to the great places of life. Let me tell you this—and I say it without fear of contradiction—that the progress of the American nation in the past has been based upon the work of the engineers; and, as civilization becomes more complex, the man of the future to solve our problems will be the engineer. Why? He deals with natural laws, finding out how natural laws want to act; and when he can correlate one substance to another, or one element to another, and bring them to a sphere of greater usefulness, that man (or men) will aid in the conservation of our natural resources, which is one of the most necessary steps for the continued progress of our nation.

There is only one other thing that I want to speak about, because it is the one thing that industry is demanding more and more of men today, and that is this: we must have men whose very foundation is character. And as we from time to time are bringing our influences, and figuratively putting our arms about these young fellows who are meeting the battles, as they go through the university, let us in our broad sympathies have the great supreme thought that you must first have character. Without character, whatever tools we may give them will be useless.

CHAIRMAN GOODALE: I will call next for a brief paper that Prof. F. Crabtree has submitted, which will be presented by Prof. F. F. McIntosh, of the Carnegie Institute of Technology.

*(Concluded in March issue TRANSACTIONS)*

IDENTIFICATION OF THE THERMAL EFFECT OF  
THE IRON-CARBON EUTECTOID  
AND  
EXTRAPOLATION OF THE HEATING AND COOLING  
CURVE VALUES TO ZERO RATES

By Anson Hayes, H. E. Flanders and E. E. Moore

*Abstract*

*In this paper, thermal analysis methods have been applied to the location of the iron-carbon eutectoid in malleable iron containing 0.95 per cent silicon.*

*This method places this important point on the iron-carbon diagram at a temperature of 771 degrees Cent. (1420 degrees Fahr.).*

*Evidence is also presented to show that Ruer's location of this point on the diagram for pure iron-carbon alloys is not conclusive.*

INTRODUCTION

THE thermal curves published by Ruer<sup>1</sup> in 1920 were interpreted by him as showing the presence of an iron-carbon\* eutectoid ( $A_1$  stable) in an alloy of a high degree of purity. He places this important point on the iron-carbon diagram, at 733 degrees Cent. (1351 degrees Fahr.), or twelve degrees higher than the iron cementite eutectoid point. ( $A_1$  metastable.) Carpenter and Keeling<sup>2</sup>, in 1904, published the results of an extensive investigation on the thermal effects in cooling iron-carbon alloys in which there appears a series of points ranging across the diagram at a temperature between 775 and 800 degrees Cent. (1427-1472 degrees Fahr.) These start sharply at 0.6 per cent carbon and extend over to the eutectic composition. This was as far as the compositions of their alloys extended. It is important to note that all of the data shown on the Carpenter and Keeling diagram were obtained from cooling curves, and are thus lower than the cor-

\*We will designate the iron-carbon eutectoid by  $A_1$  stable and the iron cementite eutectoid by  $A_1$  metastable as has been done by Schwartz.

(1) Zeit. Anorg. und Allgemeine Chemie B117H. 4 p. 249 120.

(2) Journal Iron and Steel Institute (British); No. 1, 1904.

A paper by Dr. Anson Hayes, H. E. Flanders and E. E. Moore, members of the chemistry faculty of Iowa State college, Ames, Iowa.

responding equilibrium values. Even with this lag that undoubtedly accompanies cooling curves, this series of points occur at a temperature some 47 degrees Cent. (116 degrees Fahr.) higher than Ruer places the iron-carbon eutectoid.

Another piece of work which has a direct bearing upon the location, with respect to temperature, of this point, was that of Giolitti and Tavanti<sup>3</sup> in which they showed conclusively, that no solid solution is formed until a temperature of 780 degrees Cent. (1436 degrees Fahr.) is reached. The materials used by them were low carbon steels suitable for case hardening and contained only small per cents of the so-called impurities. We thus have the work of Carpenter and Keeling and that of Giolitti and Tavanti indicating that the temperature of the iron-carbon eutectoid is 780 degrees Cent. (1436 degrees Fahr.) or higher, while that of Ruer places it at 733 degrees Cent. (1351 degrees Fahr.) in pure iron-carbon alloys.

The possibility that the series of points found by Carpenter and Keeling might represent the thermal effect of the iron-carbon eutectoid, was suggested by Hayes and Diederichs<sup>4</sup> and it was announced at that time that work was under way in their laboratory to establish or disprove this point. Due to the fact that W. P. Fishel, who was working on this phase of the problem accepted a teaching position in another institution before the work was completed, the progress of the work has been temporarily interrupted.

There are two peculiarities in regard to Ruer's work which should be mentioned. First, Ruer ran his heating and cooling curves at comparatively rapid rates (6 degrees Cent. per minute). Second, he carried the sample only to a temperature of 777 degrees Cent. (1430 degrees Fahr.) which is below that of the minimum temperature of the iron-carbon eutectoid indicated by Carpenter and Keeling, as well as that of Giolitti and Tavanti. This method of experimentation kept the sample above the critical range only 16 minutes and left only this short time for the equalization of carbon concentrations in the solid solutions formed.

Mahin and co-workers<sup>5</sup> have shown the remarkable segre-

(3) Gass. Chim. Ital. 1909 V. 39. Part II.

(4) TRANSACTIONS, American Society for Steel Treating, Vol. III, 1923, page 518.

(5) Journal of Industrial and Engineering Chemistry, Vol. XII, page 1090, 1920.

gation of ferrite caused by inclusions. It has been shown by the work of Flanders and Moore in this laboratory that marked segregation of ferrite occurs during the graphitization that takes place in the critical range, carbon acting as the inclusion. Thermal data on plain carbon steels show that the temperature of pearlite formation differs some 45 degrees Cent. (113 degrees Fahr.) when precipitated from distinctly hypoeutectoid solid solutions and from those of eutectoid composition.

The one thermal effect which remained on Ruer's cooling curves after the twelfth heating occurred at 712 degrees Cent. (1313 degrees Fahr.) a temperature between 718 and 708 degrees Cent. This is exactly the type of change in the temperature of  $Ar_1$  metastable that should accompany the equalization of the carbon content of the different solid solutions formed throughout the sample. This slow equalization of carbon concentrations might be expected to accompany the repeated heatings and coolings in case Ruer did not reach the temperature of the iron-carbon eutectoid at any time.

The above conflicting evidence has been presented in order to emphasize the fact that the location of the iron-carbon eutectoid in pure iron-carbon alloys has not been satisfactorily accomplished. It will require more conclusive data than is available at the present time. It is the purpose of the work reported in this paper, first, to identify the heat effect of the iron-carbon eutectoid and second, to locate this point in iron-carbon alloys containing about 1 per cent silicon. This silicon content is that usually found in white cast iron suitable for making malleable castings. It was reasoned that if cooling curves could be run on malleable iron at rates approaching those necessary to produce complete graphitization, the thermal effect accompanying graphitization at the iron-carbon eutectoid should become quite pronounced as compared to that accompanying the precipitation of pearlite. Accordingly attempts were made to run heating and cooling curves at very slow rates. The composition of the white cast iron from which the malleable iron used in this work was made is as follows:

Carbon	Man.	Phos.	Sul.	Sil.
2.40	0.44	0.16	0.5	0.95

The thermal curves were run with a transformation point apparatus made by the Leeds and Northrup company. In order to obtain uniform rates of heating and cooling a salt water rheostat modeled after that described by Burgess<sup>6</sup> was used. It was found necessary to use copper plates tapered toward the bottom instead of the rectangular form described by him. To overcome variations in line voltage a variable rheostat of the dial type was placed in series with the furnace and salt water rheostat. A voltmeter was connected across the salt water rheostat and furnace. Operation of the dial rheostat made it possible to hold the voltage across the salt water rheostat and furnace constant to within 0.2 volt in 106 volts. In fact the accuracy of voltage regulation was limited only by the accuracy of reading the voltmeter. Successful curves were obtained at rates of cooling as low as one third degree Cent. per minute, on malleable iron which had been heated to 870 degrees Cent. (1598 degrees Fahr.) and held for two hours just before the curve was taken.

There was always a marked heat effect whose maximum corresponded closely with that of the Ar<sub>1</sub> metastable point, and which later was shown to represent a superposition of Ar<sub>1</sub> stable and metastable. It was found, however, that a thermal effect in addition to those shown by Charpy<sup>7</sup> and Schwartz and co-workers<sup>8</sup> was quite pronounced when heating curves were run on specially prepared samples of malleable iron.

For this work samples of malleable iron suitable for use in thermal analysis work were heated to 870 degrees Cent. (1598 degrees Fahr.) for approximately two hours. These samples were then cooled at such rates as would produce varying combined carbon contents as shown in the photomicrographs of Fig. 1. Heating curves were then run at a rate as near 3 degrees Cent. per minute as could be readily done. See Fig. 2, curves 2 and 3. Rates of heating less than 1.6 degrees Cent. per minute failed to show this additional heat effect except on samples cooled at very slow rates. It is well known that samples of malleable iron which have been heated

(6) Bulletin Bureau of Standards, Vol. 10, No. 3, page 365.

(7) Charpy and Cornu-Thenard, *Journal Iron and Steel Institute*, Vol. 41, page 276.

(8) *Transactions of the Institute of Mining and Metallurgical Engineers*, No. 111818, August, 1922.

through the critical range and again cooled at rates of 5 degrees Cent. per hour or less have no combined carbon, while those that have been similarly heated, but cooled at rates of 15 degrees Cent. per minute, contain approximately a pearlitic

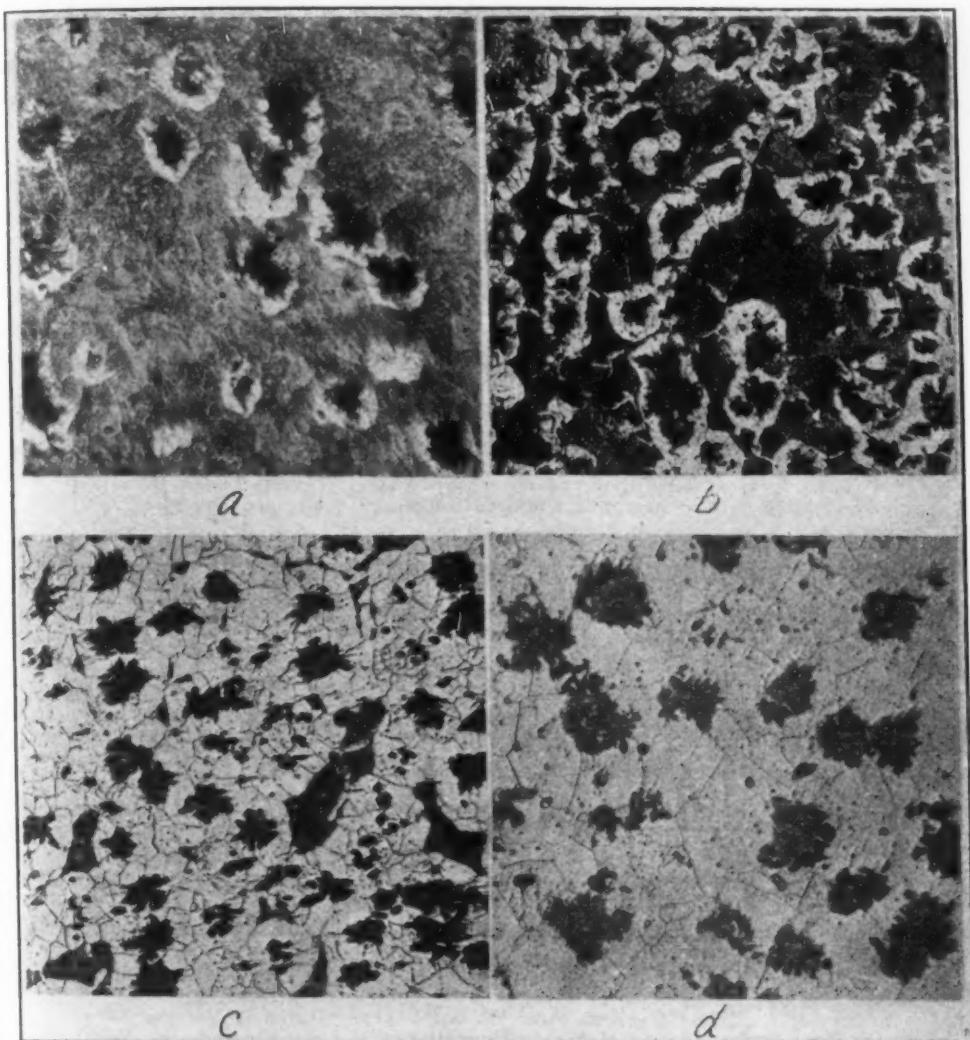


Fig. 1—Photomicrographs of Malleable Iron Heated through the Critical Range, Held for Two Hours and Cooled as Follows: a—14 Degrees Cent. Per Minute; b—2.7 Degrees Cent. Per Minute; c—0.85 Degree Cent. Per Minute; d—Untreated Malleable Iron.  $\times 100$ .

matrix. Intermediate cooling rates will of course produce varying amounts of graphitization between carbon contents of zero and that corresponding to the composition of pearlite. In Fig. 2 are shown heating curves run at a heating rate of

3 degrees Cent. per minute on samples of malleable iron which had been treated as follows: Curve 1 is the heating curve for a piece of malleable iron which had been heated to a temperature of 870 degrees Cent. (1598 degrees Fahr.) for two hours,

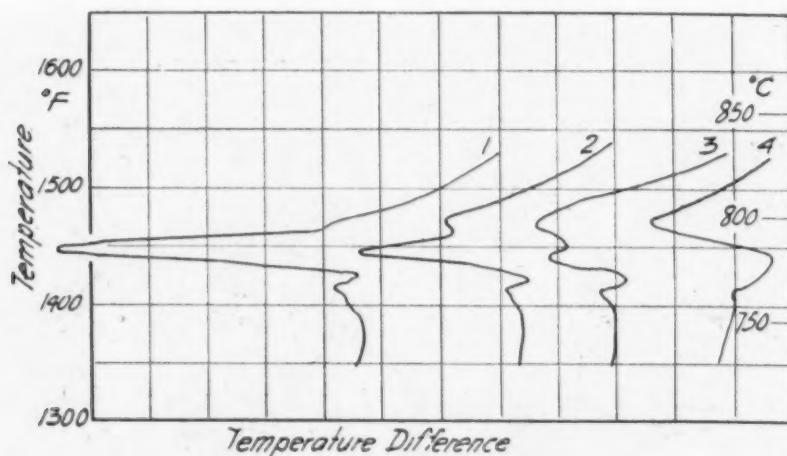


Fig. 2—Heating Curves Showing the Shift of Heat Effect from  $Ac_1$  Metastable to  $Ac_1$  Stable, as Previous Rates of Cooling are Decreased.

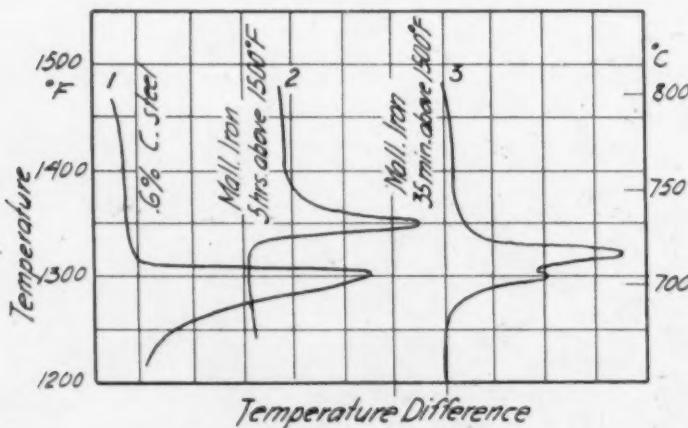


Fig. 3—Cooling Curves on Steel, Malleable Iron Heated Above the Range for Two Hours, and on Malleable Iron Heated Rapidly Through the Range and Cooled Immediately.

and had then been cooled at a rate of 14 degrees Cent. (57 degrees Fahr.) per minute. Curve 2 is that for a sample treated in the same manner as was the sample for curve 1 with the single exception that it was cooled from 870 degrees Cent. at a rate of 2.7 degrees Cent. per minute. Curve 3 is that for a sample cooled at the rate of 0.85 degrees Cent. per minute,

while curve 4 is that for a sample of malleable which contained no combined carbon. The following significance is given to the maxima shown on curves 1, 2 and 3 of Fig. 2. The one at 767 degrees Cent. (1412 degrees Fahr.) is  $Ac_2$ , that at 785 degrees Cent. (1445 degrees Fahr.) is  $Ac_1$  metastable, and that of 800 degrees Cent. (1472 degrees Fahr.) is  $Ac_1$  stable. Curve 4 differs from the other three in that  $Ac_1$  metastable is lacking, the decrease in the intensity of  $Ac_1$  metastable and the corresponding increase in that of  $Ac_1$  stable is most evident as graphitization progresses, i.e., as cooling rates become less. There is but the one interpretation of the maximum at 800 degrees Cent. (1472 degrees Fahr.) which is that it represents the iron-carbon eutectoid. Photomicrographic confirmation of this interpretation of these curves is shown in Fig. 1. These photomicrographs were taken before the heating curves were run and show plainly the variation in the amounts of pearlite to be absorbed at  $Ac_1$  metastable and of ferrite to be dissolved at some higher temperature.

The absence of  $Ac_1$  stable when heating curves were run at rates below 3 degrees Cent. per minute and on samples previously cooled at comparatively rapid rates, is explained as follows: Assume that the rate of cooling of the sample on which the heating curve is to be run has been such as to leave a combined carbon content equal to or slightly greater than that corresponding to the iron-carbon eutectoid, i.e. 0.57 per cent carbon<sup>9</sup>. The matrix structure will then be a shell of ferrite about the primary carbon spots and the remainder will be of pearlitic composition. If this metal is heated at a sufficiently slow rate, the pearlite will be dissolved at  $Ac_1$  metastable and as the temperature rises, the ferrite shell will be absorbed into this solution. Since the combined carbon content is already higher than that of the iron-carbon eutectoid value, the ferrite shell will all be absorbed into the solid solution before the temperature of this point is reached. There should, therefore, be neither carbon nor ferrite go into solution at the  $A_1$  stable point since the combined carbon content is already higher than corresponds to a solution in equilibrium with ferrite and temper carbon, and since also the ferrite has

(9) Same as Ref. (8).

all been absorbed before the temperature of the iron-carbon eutectoid is reached. The result will be that no ferrite and carbon will be dissolved at  $A_1$  stable and no heat effect will be produced.

For samples which have been cooled at rates sufficiently low so that graphitization has taken place so as to leave a combined carbon content less than that corresponding to the iron-carbon eutectoid, ferrite will remain undissolved at the temperature of  $Ac_1$  stable for all rates of heating following such treatment. The heat effect of the  $A_1$  stable point should be present for all rates of heating for such samples. The thermal effect corresponding to this point has been repeatedly obtained on samples of completely malleableized iron at rates as low as one-third degree Cent. per minute.

#### THE IDENTIFICATION OF $Ar_1$ STABLE

Although numerous attempts were made to separate the maxima of  $Ar_1$  stable and of  $Ar_1$  metastable they all resulted in but the single peak such as is shown in curve 2 of Fig. 3, when samples were used whose treatment had been such as to insure a uniform concentration of dissolved carbon throughout the piece. It should be stated that the form of curve 2, Fig. 3, is typical of all of the cooling curves run on malleable iron, although rates of cooling from 0.45 degrees Cent. per minute to 12 degrees Cent. were used. There was of course a variation in lag especially for the more rapid rates of cooling.

This portion of the problem thus resolved itself into the identification of the beginnings of the two heat effects of  $Ar_1$  stable and  $Ar_1$  metastable, without the supporting evidence of the identification of their individual maxima. This was arrived at by the considerations which follow.

The work of Schwartz and co-workers shows conclusively that the carbon content of the solid solution in equilibrium with beta iron, and carbon at the iron-carbon eutectoid is very near 0.57 per cent. From Fig. 1-C it is apparent from a consideration of the limited areas of pearlite that rates of cooling of 0.80 degrees Cent. per minute left combined carbon contents of about 0.1 per cent carbon. The point of importance is that

this is distinctly less than the combined carbon content corresponding to  $Ar_1$  stable. There must have been then a heat effect accompanying the deposition of ferrite and carbon at the iron-carbon eutectoid, since graphitization proceeded beyond the combined carbon content corresponding to that of the  $A_1$  stable. Since there was but the one maximum on the cooling curves, and since the photograph shows that both the heat effects of  $Ar_1$  stable and metastable must have occurred, we conclude that their individual maxima were superimposed.

It is a characteristic of  $Ar_1$  metastable that the heat absorption takes place sharply at a definite temperature producing an almost horizontal portion on the difference curve as in curve I, Fig. 3. In all of the cooling curves obtained from malleable iron there is a marked rounding off at the beginning of the heat effect. The form of the curve for this rounded portion is due to the wide temperature interval over which the action of  $A_1$  stable takes place both on heating and cooling. (See also Fig. 2, curve 4.) The beginning of the rounding off in the cooling curves is considered to mark the beginning of action at  $Ar_1$  stable. Thus in curve 2, Fig. 3,  $Ar_1$  stable is considered to be 758 degrees Cent. (1396 degrees Fahr.) while  $Ar_1$  metastable is considered to be at 738 degrees Cent. (1360 degrees Fahr.) The actions which were in progress during the interval between 758 degrees Cent. and 738 degrees Cent. are, the precipitation of ferrite and temper carbon due to the action of  $Ar_1$  stable, and the throwing out of enough ferrite in excess, to shift the composition of the solid solution from that corresponding to  $Ar_1$  stable to that of  $Ar_1$  metastable.

In the extrapolation shown in the next section of this paper the regularity of the variation in lag, as rates of cooling are changed, considered in conjunction with the fact that a ferrite shell was formed about the primary carbon spots for all of these rates except those that were the most rapid, lends great support to this interpretation of these curves.

The two maxima shown in Curve 3 of Fig. 3 were produced by heating a sample of malleable iron through the critical range and then running a cooling curve immediately, both heating and cooling rates being high (12 degrees Cent. per minute.) Fig. 4 is a photomicrograph of the structures

obtained by this treatment. It shows that carbon was dissolved wherever carbon and iron were in direct contact and also that some solution took place at the grain boundaries of the ferrite. The thing that seems most significant is the fact that there is such a variation in the concentration of the combined carbon in various small portions of the matrix. Due to

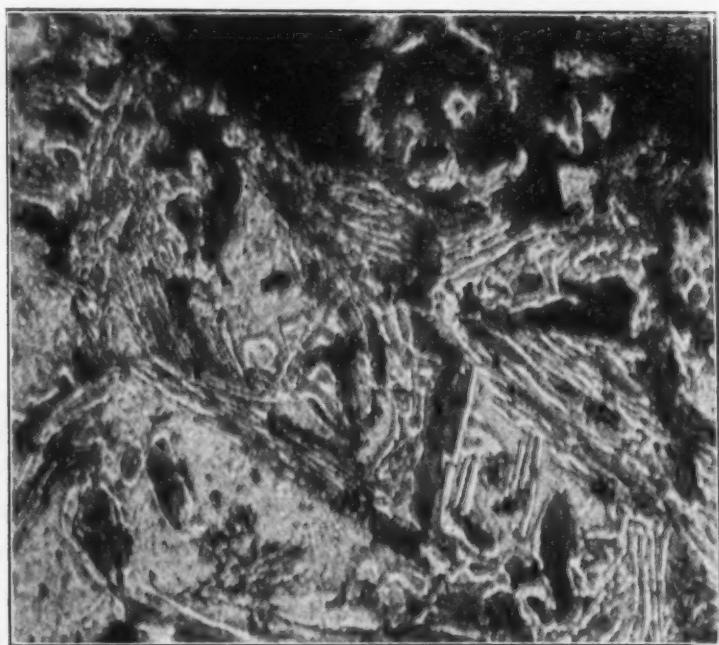


Fig. 4—Photomicrograph Showing the Structure of Malleable Iron After a Rapid Heating Through the Range Followed by a Rapid Cooling. Note Combined Carbon at Grain Boundaries and in Contact with Temper Carbon. Large Dark Areas, and Small Dark Areas in the Ferrite, are Temper Carbon. White Lamellae are Cementite. This is the Structure the Produced Curve 3 of Fig. 3. X 450.

the fact that a separation of the maxima for  $Ar_1$  stable and  $Ar_1$  metastable, could not be effected when the sample was heated above the critical range and maintained there for a sufficient length of time to allow the equalization of carbon concentrations throughout the matrix, it would seem very probable that the two maxima obtained were due to the precipitation of pearlite from two portions of the matrix of different carbon content. The treatment under which these two maxima were obtained, was similar to that used by Ruer<sup>10</sup>, although in the present work the samples were taken to a sufficiently high

(10) Same as Ref. (1).

temperature to have passed  $A_1$  stable. While the authors are not able to state that these two maxima both represent the

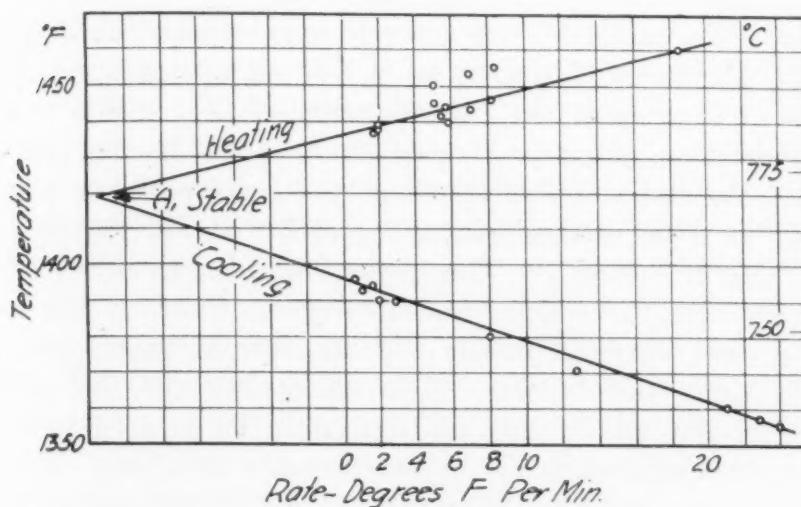


Fig. 5—Extrapolation for  $A_1$  Stable on Sample of Completely Graphitized Iron.

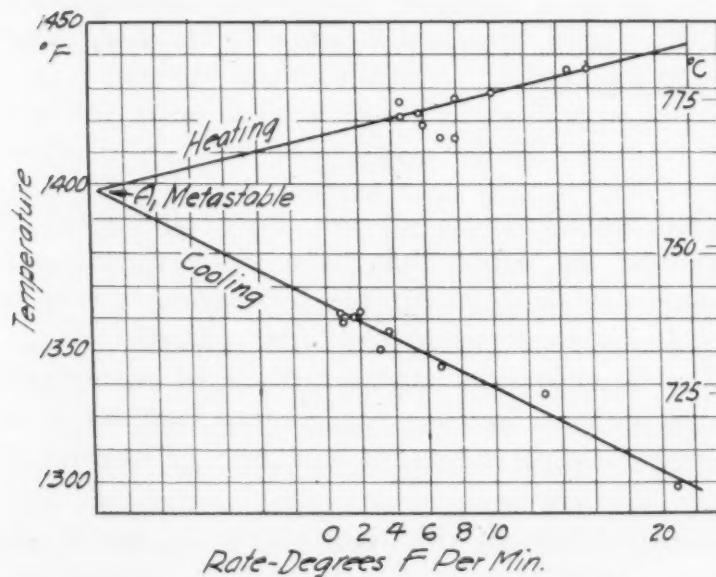


Fig. 6—Extrapolation for  $A_1$  Metastable on a Sample Malleable Iron.

precipitation of pearlite yet it must be admitted that this evidence casts great doubt upon Ruer's interpretation of his curves.

THE EXTRAPOLATION OF COOLING AND HEATING CURVES TO OBTAIN  $A_1$  STABLE AND  $A_1$  METASTABLE

The identification of the beginning of the heat effect at  $Ac_1$  stable on samples of completely graphitized iron was found possible for rates of heating from 0.45 to 12 degrees Cent. per minute. This, with the identification of  $Ar_1$  stable over the same variation of cooling rates, made possible the extrapolation for  $A_1$  stable. The result of this extrapolation is shown in Fig. 5. This method places  $A_1$  stable at 771 degrees Cent. (1420 degrees Fahr.) The cause of irregularities for  $Ac_1$  stable for rates between 5 and 10 degrees Fahr. is not known. Curves were very accurately reproducible at rates around 1.2 degrees Cent. per minute. The uniformity for the variation of lag for  $Ar_1$  stable was all that could be desired.

The extrapolation for  $A_1$  metastable is shown in Fig. 6 and places this point at 759 degrees Cent. (1398 degrees Fahr.) This agrees well with the value given by Schwartz. The cooling curves were taken on malleable iron during the cooling following the first heating after malleabilization, while the heating curves were obtained during the second heating. The result of this work places  $A_1$  stable 12 degrees Cent. higher than  $A_1$  metastable.

## SUMMARY

1. The identification of the heat effects of  $Ac_2$ ,  $Ac_1$  metastable and  $Ac_1$  stable has been made during the second and successive heatings of samples of malleable iron, and they have been found to occur in the order named.
2. The identification has been made of  $A_1$  metastable and of  $A_1$  stable both on heating and cooling samples of malleable iron over rather wide ranges of variation of heating and cooling rates.
3. Extrapolation of this data places  $A_1$  stable at 771 degrees Cent. (1420 degrees Fahr.) and  $A_1$  metastable at 759 degrees Cent. (1398 degrees Fahr.) in iron of 0.95 per cent silicon.

## RESEARCH, THE MOTHER OF INDUSTRY

By Arthur D. Little

WE ARE living in an age in which new impressions so crowd upon us that the miracle of yesterday becomes the commonplace of today. We fail to appreciate how rapidly our environment is changing, or how profoundly it has changed. In spite of the premature grayness of my residuary hair, you will, I am sure, be polite enough to agree that I am still a young man. I am, in fact, in the position of the little negro girl, who was asked how old she was. She said, "If you asks me how old I is, I'se five, but if you asks me how much fun I'se had, I'se most a hundred." When I review the industrial developments that have taken place within my recollection, I feel like the grandfather of Methuselah.

In "Mis' Nelly of New Orleans" Mrs. Fiske says, "I hate old friends, they always refer to 'that delightful Friday afternoon at the Centennial.'" You will forgive me for recalling that at the Centennial I saw, as a small boy, the first telephone and the first commercial arc light. May I also record that for ten successive days I ate Philadelphia ice cream. In 1884 I was trying to make 10 tons per day of sulphite pulp in the first mill on the continent. Today we make 7000 tons. When I opened a laboratory in Boston the street cars were drawn by horses, and I remember the clang of the first electric cars on Boylston street and the consternation they caused among their equine competitors. From my window on Beacon street 2000 bicycles an hour could be counted, where now more automobiles pass. I have seen the fish-tail burner supplanted by the Welsbach mantle and the incandescent electric lamp develop from carbon to tungsten filaments through to the white light of argon-filled bulbs. I remember the thrill with which I first saw an airplane sweep at dusk across the disk of the rising full moon and soar to invisibility above. Since then men have crossed the Atlantic in a single day and flown a mile in 13 seconds. Within a month the *SHENANDOAH*, filled with helium, has sailed majestically over the basin, which faces my office window. That evening the *Boston Transcript* printed a description of the flight sent to its office by wireless from an airplane above the airship. I went with the crowd to hear Barnum's talking machine,

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A paper presented on Dec. 7, 1923, before the Engineering Division of the National Research Council, University club, New York City.

cumbersome as a church organ, make guttural noises that bore an imagined resemblance to human speech, and later, in the Old South Church, heard Edison's phonograph, no bigger than a typewriter, reproduce a cornet solo by the passage of a needle over tin foil. Where the zoetrope excited the wonder of the children of my generation, the moving picture now bores thousands and entertains tens of millions. I still preserve the quill pen, with which I often saw my grandfather write, and during my own first years in business all our letters were in longhand and copied in a press.

I well remember the incredulity, which the announcement of the X-rays excited in some lay quarters, and the whole marvelous story of radium, which has led to altogether new conceptions of the structure of matter, is, of course, a tale of yesterday. It seems but a few short years since Herz announced the discovery of long etherial waves, which could be refracted and focussed by great prisms and lenses of pitch; yet during those years there has developed the whole wonderful system of wireless telegraphy and radio-telephony.

When I began the study of chemistry we were taught that there were certain permanent gases. They were called permanent because they could not be liquified, but, almost before I had learned the lesson, Pictet and Cailletet had liquified oxygen. There are now no permanent gases, and liquid air has become a commonplace of the laboratory and the raw material for great industries.

I was also taught that atmospheric air contained only oxygen, nitrogen, aqueous vapor, and a small proportion of carbon dioxide. As even Mr. Bryan would admit that the human race has been immersed in air for at least six thousand years and might reasonably be assumed to know all there was to know about it, I accepted the instruction at its face value. Lord Rayleigh and Sir William Ramsay were less credulous and by the most brilliant, patient, and refined research demonstrated the existence in the air we breathe of five hitherto unknown gases: argon, helium, neon, krypton, and xenon. Even their names carry interest and suggestion. Argon, the lazy one, because it forms no compounds; helium, because the spectroscope had revealed its existence in the sun before its discovery on earth; neon, the new one; krypton, the hidden one; and xenon, the stranger. But already the lazy one has been put to work in incandescent lamp bulbs; helium, with nearly the lifting

power of hydrogen and noninflammable, has become the key to the safer navigation of the air by dirigibles; while neon tubes flash advertisements in shop windows and assist chauffeurs to locate engine troubles.

In 1898, Sir William Crookes, having in mind the inadequacy of the supply of nitrogenous fertilizers for the agricultural needs of our expanding population, and speaking as president of the British Association for the Advancement of Science, said, "England, and all civilized nations, stand in deadly peril of not having enough to eat." That peril is now removed by the effective and spectacular process, developed by chemists, for the production of such fertilizers by the fixation of nitrogen from atmospheric air.

My study of chemistry began with Eliot and Storer's Manual. Its copious index contains no reference either to catalysis or colloids. Today catalysis has a copious literature of its own and is recognized as the determining factor in hundreds of reactions, on which are based new industrial methods for the production of such important and diverse materials as edible fats, ammonia, sulphuric acid, synthetic dyes, and whole series of hydrocarbon derivatives. Colloid chemistry has become no less inclusive. It permeates such industries as tanning, artificial silk, rubber, smokeless powder, celluloid, photography, and soap. It solves the problems of the makers of ceramic wares, shaving creams, and shoe blacking.

The decade beginning with 1890 was notable for great industrial developments based upon research. In that year Hall brought out the aluminum process; in 1891 Acheson began the manufacture of carborundum and made available abrasives of a new order of efficiency; in 1892 Willson established the basis for the carbide, acetylene, and cyanamid industries by his process for calcium carbide; in '93 the diesel engine was invented, Cross and Bevan communicated to me their discovery of viscose from which last year one American company made 22,000,000 pounds of artificial silk, and I demonstrated the Schultz processes for chrome tanning which have revolutionized the leather industry; in '94 the automobile was developed; at about this time I was engaged in the investigation of the new electrolytic processes of Le Sueur and others for the manufacture of bleaching powder and alkali and was producing, by laboratory methods, cellulose

acetate, the substance by which during the World war, the wings of airplanes were protected; in '95 Roengen announced the X-rays; in '96 Becquerel discovered radio-activity; in '97 synthetic indigo, the product of German technical skill and financial courage, was placed upon the market and established still more firmly German control of the dyestuff markets of the world; in '97 also Marconi sent a wireless message across Bristol channel, while 1898 will be forever memorable for the discovery of radium.

As business men, you are accustomed to forecast tendencies by the trend of plotted curves. Let me assure you that the trend of the research curve is steeply upward. Research, which has paid these heavy dividends and countless others in one decade, needs only your recognition and support to enable it to pay still more heavily in the future. The vein is constantly widening, and the instruments of research grow steadily more effective. Equally is it true that the means of reducing research results to practice are to-day incomparably better than they ever were before.

I would apologize for having given to this fragmentary and totally inadequate review so personal a tone were I not anxious to bring home to you the fact that all these great developments, so far-reaching in their influence upon industry, our mental outlook, and our entire social structure, have taken place within the easy recollection of a man still on the job. Perhaps you recognized and turned to profit some of the opportunities that these developments afforded. Whether you did or not, it is worth your while to bear in mind that another procession is forming around the corner.

Three fundamental factors are involved in industry: capital, labor, and the creative mind. The creative mind may function along the line of organization and management, or it may function along the lines of research. In any progressive civilization industry is constantly pushing its outposts forward into the new territory wrested from the unknown by its advance guard, science. Now science is merely information, so classified and organized as to be used effectively and at once, and information, to quote General Phil Sheridan, is "the great essential of success." Advance information of the result of the battle of Waterloo consolidated the Rothschild fortune. It is advance information, which may be of equal potential value, that research offers you.

Research today is extending the boundaries of every field of

human activity and thought. It is today, more effectively than ever, directing industrial expansion into new channels and new territories. We are, for example, about to witness revolutionary changes in the preparation and use of fuel. Powdered coal has already established itself in engineering practice. Much progress has been made in low-temperature carbonization with higher recoveries of chemical values and the production of artificial anthracite. The conversion of coal to liquid hydrocarbons through hydrogenation has been demonstrated on the commercial scale in Germany, though the figures on the balance sheet are doubtless still in red. The gas industry is destined to a great expansion, which will involve radically new methods. The industrial use of gas has scarcely begun, yet in Baltimore, within the last six years, more gas has been consumed than during the preceding century. Systems for the complete gasification of coal have been developed, and there are serious proposals for great gas works at the mines and the distribution of industrial gas through high-pressure mains.

Steam pressures in central stations have reached 500 pounds, and pressures of 1200 and even 1500 pounds are cautiously being tried. They present problems in the behavior and strength of steel at high temperatures in contact with water and gases that can only be solved by intensive research. The gas turbine presents other problems, which seem to be nearing a solution, but here, again, is more research required.

Decades of research have brought us to the point where we may soon expect oxygen, the supporter of combustion, to be as cheap by the ton as coal. That implies an impending revision of blast-furnace practice and of many operations in general metallurgy. It presents the possibility of the continuous gas producer and should raise the quality and heating power of industrial gas. It calls for new refractories.

Petroleum is about to be raised to a new and higher plane of usefulness and value, where it will serve as the starting point for the synthesis of whole series of organic compounds.

Biological chemistry is contributing new fermentation processes, which yield butyl and amyl alcohols, acetone, glycerine, and fats, and in its alliance with medicine is conquering some of the most terrible scourges of the human race.

In 1922 Bohr published "The Theory of Spectra and Atomic

Constitution." That, I submit, is seemingly far removed from industry and practical affairs. But Bohr's theory indicated that an unknown element should exist in zirconium-bearing minerals. In 1923 Coster and Hevesy, by means of X-ray analysis, found the element as predicted. It is named Hafnium, in honor of Bohr's city, Copenhagen. That you may the better appreciate the potentialities of this discovery let me add that Hafnium is estimated to represent one hundredth of the earth's crust and to be, therefore, more plentiful than lead, tin and many other metals of commerce.

The French chemist, Dumas, writing to Pasteur concerning Lavoisier, the father of chemistry, said:

"The art of experimentation leads from the first to the last link of the chain, without hesitation and without a blank, making successive use of reason, which suggests an alternative, and of experience, which decides on it, until, starting from a faint glimmer, the full blaze of light is reached."

Our prosperity in the past has been largely based on cheap land and superabundant raw materials. Today our civilization has developed such complexity that we cannot hope to maintain our position except through the assistance which only science can afford. The laboratory has become a prime mover for the machinery of civilization, and the evidence that has been placed before you justifies the claim that there is a direct obligation upon industry to support research with the generosity of an enlightened self-interest, for Research is the Mother of Industry.

## CHARACTERISTICS OF HEATING CURVES THEIR APPLICABILITY FOR CALCULATING THE TIME REQUIRED TO REACH CONSTANT HEAD TEMPERATURES

By E. J. Janitzky

### *Abstract*

*This paper outlines a method of calculating the time required to bring bodies of steel up to the constant head temperature of the furnace. This method uses an experimentally determined time constant and the number of time constants derived from the characteristics of a heating curve, instead of physical constants, such as specific heat, conductivity, etc., ordinarily used in this class of calculation.*

BY HEATING a solid body at constant heat potential under the assumption that it does not possess transformation points similar to those of steel, we note that at the start of heating, the magnitude of temperature increase is very great and decreases rapidly as it approaches the temperature limit to which it is heated. The temperature rise in heating steel or iron will show interruption or retardation at certain points.

In all metallurgical furnaces the charge is heated up, or kept hot, partly by direct contact with the gaseous products of combustion and partly by radiation from the flame and the sides and roof of the furnace. The heating curves derived and dealt with in this article were obtained by heating the specimens in a closed electric muffle furnace and therefore the heat transfer was entirely by radiation of the furnace walls.

In plotting the time as abscissa and the temperature as ordinate, one obtains a curve of the shape as shown in Fig. 1, which was replotted from the spherical temperature recording pyrometer chart.

As to the character of the curves, the writer does not intend to

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The author of this paper, E. J. Janitzky, is metallurgical engineer with the Illinois Steel Company, South Chicago, Illinois.

interfere with the prevalent contentions, but endeavors to present his observations on heating curves obtained in muffle furnaces at constant heat potential.

#### PROCEDURE

The writer heated cylindrical steel specimens by charging them into an electric resistance furnace, 3 x 4 x 9 inches, which had previously been brought up to a constant head temperature. The size of the specimen was  $\frac{7}{8}$  inch in diameter and 2.5 inches in length, with a central hole of  $\frac{7}{32}$  inch half the length of the specimen for inserting the pyrometer couple. The couple was of platinum and platinum-rhodium connected to a time-temperature recorder as made by the Brown Instrument Co. of Philadelphia. This instrument records the temperature every minute.

It was found that the results of the time-temperature curves of the heated specimen, lend themselves to simple calculations, and the data obtained are very useful in metallurgical heating problems.

The salient point of the mathematical procedure is the adoption of a time constant similar to the way the writer applied his calculations pertaining to air cooling curves (radiation and convection), and published under the title, "Characteristics of Air Cooling Curves" in Volume III of TRANSACTIONS, page 335.

In order to obtain the time constant for heating, the time is sought which is required to heat up to a temperature ( $t^\circ$ ) which

$T^\circ$

is equal to  $(T^\circ + 1) - \frac{4}{4}$ , in which equation  $T^\circ$  is the head tem-

perature in the Fahrenheit scale.

Having the time constant in linear length and plotting it in multiples from zero on the X-axis, which represents the time co-ordinate, one obtains by projecting the units of the time constants as ordinates, (as visible on Fig. 1) points of intersection with the actual curve.

The temperatures obtained at the intersection points coincide with numerals derived by dividing the head temperature by the amount of time constants ( $t$ ) or their fractions elapsed during heating plus one, raised to its own power, or  $(t + 1)^{(t+1)}$  and subtracting the quotient from  $(T^\circ + 1)$ .

The formula mathematically expressed will read:

$$t^\circ = (T^\circ + 1) \cdot \frac{T^\circ}{(t + 1)^{(t+1)}}$$

and the actual time  $T = t \times m$ ;  $m$  being the time of the time

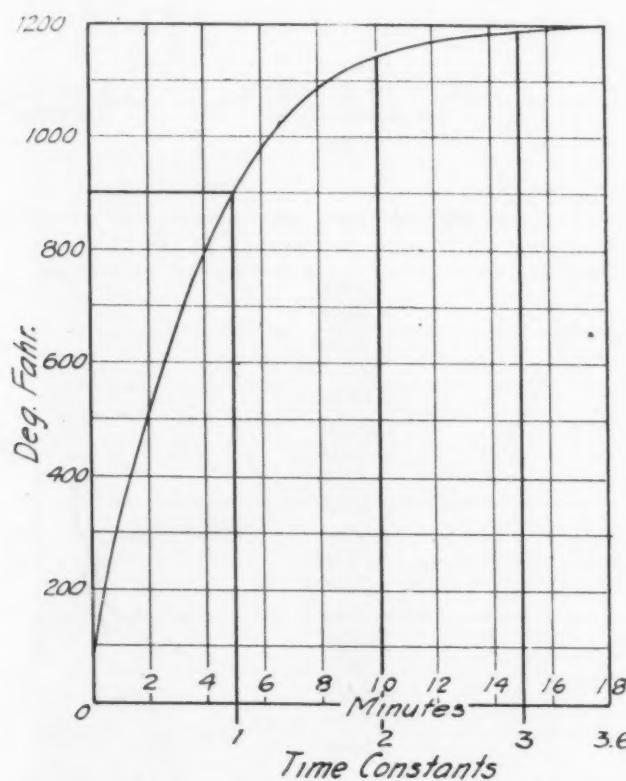


Fig. 1—Characteristics of Heating Curves, Time versus Temperature for a Standard Specimen.

constant in minutes, seconds, or hours, and  $t$  the number of time constants elapsed until reaching the head temperature.

Following is a table of the temperatures as read off Fig. 1 and as calculated for the various time constants.

$T^\circ$ Maximum Temp.	Temperature as read off °F.	$t^\circ$ Temperature as calcu- lated °F.	$t$ As elapsed in con- stants	Time $T$ in min- utes
1200	75	0	0	0
	900	901	1	5
	1142	1156	2	10
	1190	1196	3	15
	1200	1200	3.6	18

The following table shows the number of constants elapsed for heating curves to given head temperatures, from 500 to 2200 degrees Fahr., as well as the time constants in minutes for the standard specimen. This specimen was a  $\frac{7}{8}$ -inch round of 0.30 per cent carbon steel. The curves of Fig. 2 may be used for interpolating at intermediate temperatures.

Head Temp. Deg. Fahr. $T^{\circ}$	Number of Constants (t) for Given Head Temp.	Time Constants in Minutes for Std. Specimen (m)
500	3.2766	12.00
600	3.3507	10.00
700	3.4129	8.58
800	3.4665	7.50
900	3.5136	6.66
1000	3.5556	6.00
1100	3.5933	5.45
1200	3.6278	5.00
1300	3.6593	4.61
1400	3.6884	6.30
1500	3.7156	5.15
1600	3.7408	4.58
1700	3.7645	4.22
1800	3.7868	3.95
1900	3.8079	3.72
2000	3.8278	3.53
2100	3.8468	3.38
2200	3.8647	3.25

Obviously, the time constant holds only for the same shape and mass. For larger masses of geometrical similarity, the time constant increases in a manner as the surface per cubic inch decreases with increased sections, namely, hyperbolic.

In respect to specimens where the curve is interrupted by a transformation point, one has to deal with two curves, namely, the one representing the temperature rise from ordinary air temperature to the critical point, and the other, setting in at the temperature after the heat absorption is completed, to the head temperature. Both curves practically represent a unit, which is, however, interrupted by the time of the transformation period. By shifting the upper part of the curve parallel to the X-axis, amounting to time absorbed by the transformation, one obtains a graph which closely approximates the actual curve.

The formula for correlating this data holds good only when one does not consider an internal temperature gradient, that is, the conductivity  $\lambda = \infty$ . With sufficient accuracy this formula can

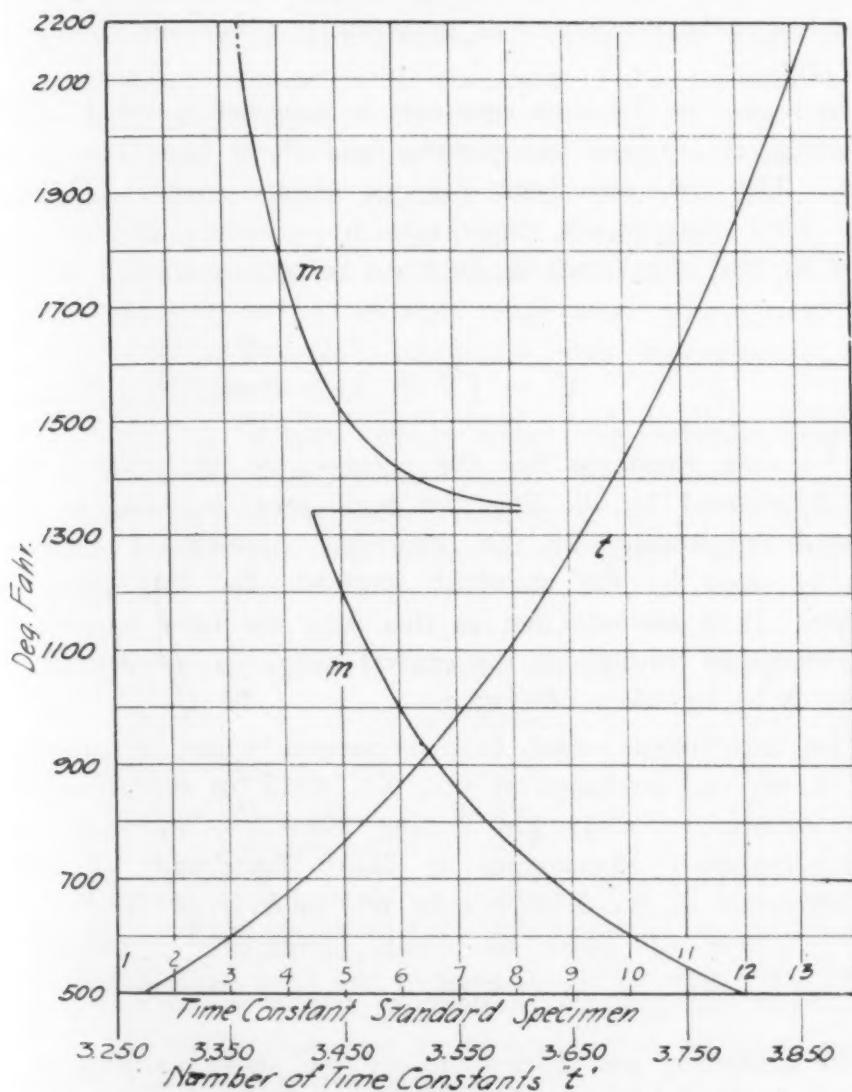


Fig. 2—Characteristics of Heating Curves, Number of Time Constants ( $t$ ) versus Temperature and Time Constants for Standard Specimen ( $m$ ) versus Temperature.

be applied for bodies of a large conductivity numeral (e. g., iron  $\lambda = 50$ , copper  $\lambda = 330$ ) and only thin sections.

In dealing with larger masses a correction must be applied on account of the ever present temperature gradient before reaching the heat potential to which it is heating.

By comparing available actual data one comes to the con-

clusion that by the addition of one to the amount of time constants required for a given heat potential the deficiency is balanced, therefore, the formula for rounds over  $\frac{7}{8}$  inch and other shapes will read  $T = m(t + 1)$ . Obviously the  $\frac{7}{8}$ -inch round has to be considered as criterion in which the conductivity  $\lambda = \infty$ .

In regard to the time constants it may be said that one has to distinguish between those under and those above the critical range. The time constants for the points under the critical range were determined empirically by counting the time required to heat the standard specimen to a temperature which is equal to:

$$t^{\circ} = (T + 1) - \frac{T}{2^2}$$

The time constants for the points over the critical range were determined by dividing the total time required to reach the head temperature by the theoretical number of time constants required by the standard specimen for this head temperature. It is obvious that in this way the time required for heat absorption throughout the critical range is included and no account is to be taken otherwise.

The experiments used for comparison were performed by M. E. Leeds and published in Vol. XV, 1915, of the *Proceedings* of the American Society for Testing Materials, under the title: "Some Neglected Phenomena in Heat Treatment of Steel." The correlation of the 18-inch cube was taken from E. F. Law's paper, "Effect of Mass on Heat Treatment," published in Vol. XCVII, 1918, of the *Journal of the Iron and Steel Institute*, London.

The following are descriptions by the above authors of the experiments which they performed:

"The experiments were conducted in a Rockwell oil burning furnace. The temperature of the furnace, controlled by two pyrometers, was first brought to that to which the specimen was to be heated and held at least one-half hour. The cold specimen was then placed in the furnace. This immediately lowered the furnace temperature (never more than 200 degrees Fahr.) and it

was again brought up as quickly as possible to that desired and held there until the specimen assumed approximately the same temperature."—Leeds.

"The cubes, supported on knife edges, were heated in gas-fired treatment furnaces in which the flame did not come in contact with the cube. The furnace was raised to a temperature of 1650 degrees Fahr. the cube charged and the furnace then maintained at constant temperature of 1650 degrees Fahr. until the cube attained the same temperature as the furnace.....

"After being in the furnace for about 4.5 hours, the cube attained a uniform temperature throughout its mass, which practically coincides with the temperature of the furnace."—Law.

Following is a table which shows the different lengths of time required to heat various shapes to various temperatures as calculated by the methods described in this paper, as well as the approximate observed times from Leeds' and Law's experiments.

Temperature to which specimen is to be heated Degrees Fahr.	Shape	Calculated length of time Hours $m(t + 1)$	Observed length of time (approximate) Hours
1650	18-inch cube	4.75	4.5
1600	12-inch round	4.97	4.7
1500	8-inch round	3.70	4.0
1400	8-inch round	4.50	4.8
1200	8-inch round	3.53	3.5
1000	8-inch round	4.17	4.2

Following are sample calculations showing the method to be used in calculating the time required to heat different sizes and shapes to a given head temperature.

#### Time Required to Heat an 18-inch Cube to Constant Head Temperature of 1650 Degrees Fahr.

Surface per cubic inch of steel of a cube or sphere of a side or diameter of: 0.875  
 inch  $= 6 \div 0.875 \dots \dots \dots = 6.857$  square inches  
 18 inches  $= 6 \div 18 \dots \dots \dots = 0.333$  square inches  
 Ratio between cube and round  $= 6 \div 4 \dots \dots \dots = 1.50$   
 Time constant of a 0.875-inch round for 1650 degrees F. (Derived by experiment),  $m = 4.38$  minutes

Time constant of a 0.875-inch cube for 1650 degrees Fahr. $(4.38 \div 1.5)$ .....	=	2.92 minutes
Time constant of a 18-inch cube for 1650 degrees Fahr. (Derived by calculation) $6.857 \times 2.92 \div 0.333$ .....	=	60.2 minutes
Number of time constants required to reach 1650 degrees Fahr. ....	=	3.755
Time required to reach 1650 degrees Fahr. $T = m(t + 1)$ .....	=	285 minutes
	=	4.75 hours
Experiment by Law (approximate) .....	=	4.5 hours

**Time Required to Heat an 8-inch Round to Constant Head Temperature of 1200 Degrees Fahr.**

Surface per cubic inch of a 0.875-inch steel round $4 \div 0.875$ .....	=	4.571 square inches
Surface per cubic inch of an 8-inch steel round $4 \div 8$ .....	=	0.500 square inches
Time constant of a 0.875-inch round for 1200 degrees Fahr. (experiment) .....	=	5.00 minutes
Time constant of an 8-inch round for 1200 degrees Fahr. (calculated) $4.571 \times$ $5.00 \div 0.500$ .....	=	45.71 minutes
Number of time constants required to reach 1200 degrees Fahr. ....	=	3.630
Time required to reach 1200 degrees Fahr. $T = m(t + 1)$ .....	=	211 minutes
	=	3.53 hours
Experiment by Leeds (approximate) .....	=	3.5 hours

### CONCLUSION

In conclusion the writer desires to direct attention to the following considerations. While this formula is based entirely on furnace wall radiation, the foregoing calculations check closely with the experimental heating times, as reported by Leeds and Law, to show its applicability to commercial heat treating furnaces.

The formula is entirely empirical in character and the constants such as specific heat, thermal conductivity, and radiating coefficients, which enter into the customary heating calculations here, are all included in the time constant and number of time constants, and these have been experimentally determined. Variables such as the condition of the specimen surface, may be neglected, since the same variables operate on the standard specimen during the experimental determination of the time constants.

There is no intention to interfere with the prevalent contentions relative to heating problems, but, rather to offer a new method of attacking the problem, and stimulate more work along similar lines.

WRITTEN DISCUSSION OF PROFESSOR ALBERT  
SAUVEUR'S PAPER ENTITLED "CRYSTAL-  
LIZATION OF IRON AND ITS ALLOYS"

By O. W. Ellis

PAPER PUBLISHED IN TRANSACTIONS, JULY, 1923

IN ANY discussion of the crystallization of steel, the writer is of the opinion that consideration should be taken of the peritectic reaction which ensues in pure carbon-iron alloys containing from 0.07 to 0.81 per cent carbon. This reaction occurs at 1486 degrees Cent. (2706 degrees Fahr.) (Ar4) between the dendrites of solid solution of carbon in  $\delta$ -iron, which have formed in the interval

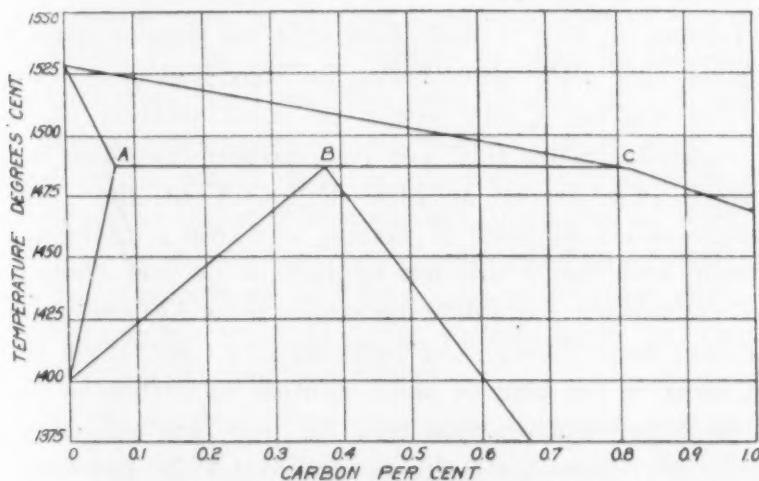


Fig. 1—A portion of the iron-carbon equilibrium diagram

of temperature between the liquidus and Ar4, and the melt existing at this temperature (see Fig. 1). Reference to Fig. 1—a portion of the carbon-iron equilibrium diagram—will make it clear that on arrival at 1486 degrees Cent. the alloys of iron and carbon containing from 0.07 to 0.81 per cent carbon consist, under conditions of equilibrium, of varying proportions of (i) solid solution, A, of carbon in  $\delta$ -iron, containing 0.07 per cent carbon and of (ii) liquid solution, C, of carbon in iron containing 0.81 per cent carbon.

At 1486 degrees Cent. these two phases react. In the case

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of the alloys containing from 0.07 to 0.38 per cent carbon the products of the completed reaction are (i) solid solution, A, of carbon in  $\delta$ -iron containing 0.07 per cent carbon (ii) solid solution, B, of carbon in  $\gamma$ -iron—austenite—containing 0.38 per cent carbon. In the case of the alloys containing from 0.38 to 0.81 per cent carbon the products of the completed reaction are (i) solid solution, B, of carbon in  $\gamma$ -iron containing 0.38 per cent carbon and (ii) liquid solution, C, of carbon in iron containing 0.81 per cent carbon.

The alloys of iron and carbon containing less than 0.38 per cent carbon being of greater importance in so far as their use in the production of castings is concerned, attention will be concentrated on their behavior in cooling and as an example the 0.20 per cent alloy may be considered.

Reference to Fig. 1 will show that on slow cooling from the liquid state this alloy commences to freeze at a temperature of about 1518 degrees Cent. Nuclei of solid solution of carbon in  $\delta$ -iron containing about 0.02 per cent carbon crystallize out at this temperature. On arrival at 1486 degrees Cent. there are present two phases—solid solution of carbon in  $\delta$ -iron containing 0.07 per cent carbon and liquid solution of carbon in iron containing 0.81 per cent carbon—in the following proportions by weight: 82.4 and 17.6 per cent respectively. At 1486 degrees Cent. these two phases react to form 58 per cent of solid solution of carbon in  $\delta$ -iron containing 0.07 per cent carbon and 42 per cent of solid solution of carbon in  $\gamma$ -iron—austenite—containing 0.38 per cent carbon. On further cooling the proportions of these solid solutions present in the alloy change—on arrival at 1440 degrees Cent., only 78 degrees Cent. below the liquidus, the one phase, austenite, alone is present.

The conditions assumed above are ideal only. In practice the rates of cooling of steel castings are high in the temperature range referred to and the approach to equilibrium is remote. As a matter of fact the conditions of cooling of steel castings are just such as would result in the formation of structures typical of peritectic alloys—structures characterized by the presence of “reaction rings.” For example, it would be expected in the case of 0.20 per cent carbon steel that there would be present in any given section of the alloy examined microscopically, evidence of the existence at some

period during cooling of (i) solid solution of carbon in  $\delta$ -iron containing rather less than 0.07 per cent carbon and of (ii) austenite containing rather more than 0.38 per cent carbon—the possibility of very high contents of carbon—of course not more than about 0.81 per cent—does not seem to be out of the question. These two constituents would be separated in a section by a reaction band such as is characteristic of peritectic alloys.

The mutual solubilities of carbon and of phosphorus in  $\delta$ -iron being unknown it is difficult to portray the progress of the solidification of phosphoric steel accurately. If, however, it is assumed that in the case of steels containing phosphorus the solid solution of carbon in  $\delta$ -iron is relatively free from phosphorus, then, on arriving at Ar4, phosphoric 0.20 per cent carbon steel will comprise the following constituents—a solid solution of carbon in  $\delta$ -iron (practically pure iron) and a melt of carbon and of phosphorus in iron. If the rate of cooling is high, as in practice, reaction between the liquid and the solid phases at Ar4 will be incomplete and at temperatures immediately below Ar4 there will exist constituents which will permanently impress their image on the structure of the steel as cast, viz., dendrites of solid solution of carbon in  $\delta$ -iron—practically pure iron, fillings of solid solution of carbon and phosphorus in  $\gamma$ -iron and, if reaction rings may be termed constituents, reaction rings intermediate in composition between the dendrites and the fillings.

In Fig. 2 (cf. Fig. 18 of Professor Sauveur's paper) an endeavor has been made to visualize the structure of phosphoric 0.20 per cent carbon steel at various stages of cooling. For example, at Ar4, prior to the peritectic reaction, there are present (i) dendrites of solid solution of carbon in  $\delta$ -iron (approximately 58 per cent by weight)—represented by both the black and the cross-hatched areas of Fig. 2—and (ii) liquid (approximately 42 per cent by weight)—represented by the white areas of Fig. 2. Subsequent to the reaction at Ar4 there are present (i) those portions of the dendrites that were unaffected by the peritectic reaction—represented by the black areas of Fig. 2, (ii) those portions of the dendrites that reacted with the liquid to form austenite intermediate in carbon and phosphorus content between the dendrites and the true fillings—represented by the cross-hatched areas of Fig. 2—and (iii) phosphorus-rich austenite tending in composition

toward 0.38 per cent carbon, but actually richer in carbon on account of the incompleteness of the peritectic reaction.

On further cooling the steel the unaltered portions of the dendrites are subject to transformation. At a temperature of 1415 degrees Cent. or thereabouts the dendrites will have wholly changed to austenite. If prior to arrival at 1415 degrees Cent. the dendrites have not been absorbing carbon, it is likely that on



Fig. 2

arrival at 1415 degrees Cent.—the  $\delta$ - $\gamma$  change being complete—they will begin to absorb carbon from the adjacent reaction rings. Meanwhile the reaction rings—relatively low in phosphorus content—will have been absorbing carbon from the fillings, ready as the fillings are, on account of their high content of phosphorus, to rid themselves of carbon. The absorption of carbon by the unaltered portions of the dendrites will be pursued as the temperature falls—ultimately all the carbon will be absorbed from the rings and the fillings by the pure austenite concentrated at the centers of the axes of the dendrites. Hence, on arrival at the lower transformation range—the  $\gamma$ - $\delta$  range—there will be present (i) pure austenite of high carbon content—represented by the black areas of Fig. 2; (ii) ferrite low in its content of phosphorus—represented by the cross-hatched areas of Fig. 2 and (iii) ferrite high in its content of phosphorus—represented by the white areas of Fig. 2.

In the case of the steel the photomicrograph of which is shown in Fig. 18 of Prof. Sauveur's paper, the carbon content of the high carbon austenite which constitutes the centers of the axes of the dendrites approximates to 0.85 per cent. If the writer's conjectures are correct the carbon content here has been determined solely by the extent to which the peritectic reaction has been pursued, i.e., by the rate of cooling of the steel. A slower rate of cooling would, owing to the greater progress of the peritectic reaction, have reduced the volume occupied by the solid solution of carbon in  $\delta$ -iron subsequent to Ar4 and its ultimate percentage carbon content would have been enhanced, since the carbon would have been concentrated into a lesser volume. It remains to be proved whether the areas occupied by the black portions of Fig. 2 would increase or decrease according as the rate of cooling of the steel increased or decreased.

There will be seen to be some difference in the interpretation of this structure (Fig. 18) from that given by Prof. Sauveur. The writer, however, was so struck by the similarity of the "intense coring effect" shown in Figs. 16 and 18 to that observed in peritectic alloys that he felt some explanation of the same might be forthcoming along the lines dealt with above.

Four points may be raised in closing; one statement, three questions:—

(1) It is the 0.38 per cent carbon steel that is possessed of the shortest range of solidification. A study of this steel should, therefore, be of special interest in this connection.

(2) May not granulation be entirely associated with the  $\delta$ - $\gamma$  transformation? Of course there is a *range* of transformation. This, however, differs much from Belaiew's *zone*. In other words, is there such a thing as a zone of granulation?

(3) Is it significant that the hyper-eutectoid steels are not subject to the  $\delta$ - $\gamma$  transformation?

(4) How will the completeness or incompleteness of the peritectic reaction affect the microstructure of the steel—is it not likely that, other things being equal, the more complete the reaction the finer the grains?

## WRITTEN DISCUSSION OF PROF. ALBERT SAUVEUR'S PAPER ENTITLED "CRYSTALLIZATION OF IRON AND ITS ALLOYS"

By E. E. Thum

PROF. SAUVEUR'S paper is essentially a review of the relationship between macrostructure and the properties of a finished metallic article. It is chiefly valuable, I think, from the questions it asks rather than the problems it answers. If it stirs up sufficient curiosity to cause some people to make some experiments, its purpose will be amply served.

So with the idea of calling attention to places where differences of opinion may readily exist—chiefly because of a lack of experimental evidence—some fundamental points will be discussed in detail.

Prof. Sauveur adopts Tschernoff's conception of the growth of metallic crystals: He postulates the first appearance of a skeleton of axial members (Figs. 3 and 12), which is later filled in by solid material. That such skeleton-forms as pictured can appear from molten steel is more than doubtful.

It is comparatively easy to crystallize thin spire-like skeletons or gossamer needles from aqueous solutions; but analogies to melted metal must be drawn with great care. Atoms or molecules in aqueous solution at atmospheric temperature have almost an infinite degree of mobility as compared to that of their brothers who have attached themselves to the growing crystalline solid. In a solidifying melt of steel, 1500 degrees hotter, the atomic activity in the just solidified particles of austenite, is very much higher than in a crystal of salt, for example. Crystallizing or directional forces are paramount in frost on a window pane; in mushy steel the forces of surface tension increase greatly in importance. Surface tension will attempt to encompass the maximum volume with the least surface. Ask yourself, therefore, whether a needle-like axis as shown in Fig. 12, all surface and no mass, could ever form in molten steel, when we know that surface forces are strong enough to spheroidize cementite in solid iron, very much

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The author, E. E. Thum, is metallurgical engineer with the Linde Air Products Co., New York City.

cooler and very much less plastic. The steel dendrite shown in Fig. 6 (Tschernoff's crystal) is good evidence that the crystallizing forces have been able to exert themselves by causing accelerated growth in the directions of the crystallographic planes. Nor is the development by etching of dendritic markings evidence of the primary existence of a skeleton or axial structure—remember that the markings are the intersections of the crystalline planes, not the axes, with the polished surface.

Following these thoughts to a conclusion, one is inclined to dispute the dictum that "Crystals grow through the successive addition of small crystalline units." Much here depends upon the definition of the adjective "small." In general, crystals appear to grow by layers rather than by chunks, that is to say, atom by atom rather than crystal by crystal. I am not aware that the mechanism of solidifying austenite has ever been directly observed, but recrystallization of light alloys at moderately elevated temperatures has been carefully studied by Prof. Carpenter. He finds that growing crystals start from invisible centers, extend their boundaries gradually in all directions and absorb their less fortunate neighbors, as the tide laps further and further up a sandy beach. Here growth by accretion seems to be atom by atom.

Returning to the idea that surface faces in a solidifying melt have great importance, is it not plausible to suppose that the atoms at and near the surface of a crystal would have anything but a regular orientation? Obviously the forces acting on an atom at the very outside of a solid are unbalanced and quite different from those acting say 10 atom-layers deep. Within the body of the solid, forces are acting in all directions, and this balance is doubtless responsible for the regular placement of the atoms in the space lattice.

The moment the existence of the quasi-amorphous surface of a hot crystal is granted, it immediately follows that forces which are incapable of orienting a single atom into its correct position in a space lattice would certainly be incapable of juggling the relatively huge masses known as "small crystals" into line. Colloidal particles gravitating to the larger masses might be pulled down and spread out into a thin layer like oil wetting a surface.

To me it seems far more reasonable to suppose that a crystal forming from a melted alloy appears first as an amorphous blob, a

solid of little rigidity but considerable atomic mobility. As this quasi-solid grows in size (atom by atom) the central portion arranges itself in regular order, i. e., crystallizes. According to this conception, crystallization takes place inside a surface film which continually grows by accretion of sluggishly-moving molecules or colloids in its vicinity, but the film never grows thick, because the underlying metal continually crystallizes as soon as it is deep seated enough to outgrow the effect of unbalanced surface force.

Prof. Sauveur pays much attention to Belaiew's "granulation theory," and seems to endorse it, although he does not say so directly. It is unfortunate that the word "granulation" is not defined, for it may mean several things. As I understand it, the "granulation theory" postulates that shortly after the molten steel has solidified into a mass of interlocking dendrites, the solid metal changes into an aggregate of much smaller grains, of roughly polyhedral outline. Assuming that "granulation" means the same as recrystallization—which would cause the above described effect—I may be pardoned for asking point-blank, "Is there any evidence that a primary dendrite of austenite recrystallizes before reaching the well known Ar transformations?" Prof. Sauveur expressly excludes the possibility of  $\Delta$  iron, which might be used to explain recrystallization of austenite.

I have read a number of Belaiew's writings available in English text, and find nowhere in them any experimental evidence of his "granulation theory." Yet it ought to be demonstrable. For instance, does the structure of raw steel casting differ, with the speed with which it traverses the temperature from liquidus to  $A_3$ , if the composition, speed of solidification, and rate of cooling below  $A_3$  are equal in all samples? In answering this question means must be adopted to evaluate the effect of more thorough diffusion of carbon, phosphorus and oxygen during slower cooling, which undoubtedly makes for coarser secondary crystallization. As far as I am aware, the literature contains no evidence on this question, which certainly must be answered before the "granulation theory" can be accepted.

Is it not plausible to explain secondary crystalline structure or microstructure by the simpler assumption that the large austenitic dendrites remain intact until gamma iron transforms to alpha iron, and thereupon disintegrate into smaller units? There is no more reason, for instance, to suppose that one crystal of solid solution

should produce one single mass of pearlite surrounded by excess constituent, than to suppose that but one crystal of austenite should form from a melted solution. Primary and secondary crystallization *both* start from many nuclei nearly simultaneously, and with apparently little or no law or order. Hence the independence of microstructure and macrostructure.

Lastly, one asks with Prof. Sauveur, "What is the cause of the dendritic markings in steel?"

It is generally held that they are the effects of quite insoluble impurities, insoluble because so persistent. May I point out that many microscopic appearances are persistent, and yet are caused by iron carbide, a very soluble substance? Furthermore, I would call attention to these facts:

If dendritic segregation is caused by something which is insoluble in the just solidifying primary crystals, this insoluble matter certainly should predominate at the boundaries. Does it? Examination of the views shown by Prof. Sauveur (e. g. Fig. 14) shows no trace of boundary segregation. In fact, the statement is often made that the boundaries of the primary dendrite are quite difficult to develop, a circumstance which indicates anything but the presence of accumulated impurities.

Second, if dendritic segregation is caused by something which is insoluble in the just solidifying primary crystals, why should not there exist a very pronounced "coring" effect in each dendrite—quite pure in the regions first frozen, and gradually becoming more contaminated to the very edge? Such coring of the macroscopic grains developed by pickling is notably absent—see for instance Fig. 27. Whatever causes the effect is certainly uniformly distributed edge to center in the large units. Belaiew also shows a section cut across a large dendrite like Fig. 6; it has characteristic dendritic markings along the crystallographic planes, as well developed at the center as at the very edge. The last clause is important: "as well developed at the center as at the edge."

Does it not fit better with the facts to suppose that during and just after solidification, the primary crystals of austenite in a well made steel consist of a mass of quite uniform solid solution? Coring is all but obliterated by rapid diffusion at those temperatures. As it cools, some substance becomes insoluble, and is rejected from solution, not to the boundaries of the crystal—too far a distance

—but to the main cleavages. This is the stuff which causes the so-called "dendritic" markings, roughly delineating the crystalline planes. (In passing it may be mentioned that the English investigator Hughes has published evidence in support of his view that regions of high phosphorus content apparently quite stable, immovable, and insoluble under usual heat treatment, diffused readily and rapidly at a certain range of temperature above  $Ac_3$ . Arriving at the gamma-to-alpha transformation, then, is an aggregate of dendrites, each of which is composed of blocklets having the same orientation, but each blocklet merging into its neighbors through regions contaminated with an excess of this now insoluble impurity.

Perhaps this is the "granulation" imagined by Belaiew. Or, "granulation" may mean the fracture of a primary grain from forces imposed by crowding among its neighbors, or from shrinkage stresses or by cooling compression. Dr. Ancel St. John informs me that certain alloys are fragmented, possibly from such causes—large crystals of uniform etching characteristic are shown by the X-ray to consist of a multitude of tiny crystals, each slightly rotated from the orientation assumed by its neighbors.

Granulation may thus mean almost anything. I plead for a specific definition of this term.

Come from these attractive theoretical discussions, to more "practical" matters! In view of the close (even if not understood) relation between dendritic segregation and fiber, forgemen will doubtless question the statement made on page 45 that "persistent dendritic segregation is always harmful and should if possible be prevented or reduced." Prof. Sauveur has done a service to the art by presenting such bones of contention as these. Nothing makes a man bristle more sharply than to have his pet prejudice flatly contradicted. And it is well these matters should be broached in the Pittsburgh meeting, for here are the steel makers; and as the *Iron Age* has said in a recent editorial, "Since the fracture of a specimen is primarily influenced by idiosyncrasies developed during solidification, while the metal is passing from the liquid to the solid state in the mold, it lies in the province of steel makers, rollers and smiths to explain the riddle of fracture."

## WRITTEN DISCUSSION OF PROFESSOR ALBERT SAUVEUR'S PAPER ENTITLED "CRYSTAL- LIZATION OF IRON AND ITS ALLOYS"

By Colonel N. T. Belaiew

**C**OLONEL BELAIEW (London) wrote to express his deep appreciation of this paper. Ever since the early days of the "Metallographist" he, in common with many others, was waiting for every article which would fall from Professor Sauveur's pen, and, if there was anything he regretted, that was only the rarity of these contributions. The more reason they had now to be thankful to the author for his masterly treatment of the subject of crystallization of iron and steel.

There are, however, some considerations which he (Colonel Belaiew) would like to put forward as a small contribution to a study which had always fascinated him.

The first question which is quite rightly emphasized by the author is the question of "primary crystallization," of its "dendritic" character and of the chemical heterogeneity of the dendrites. The author further quotes the respective opinions of Stead and of Le Chatelier, as to whether the persistent dendritic segregation is mainly due to the influence of phosphorus or to that of oxygen, and closes the paragraph by concluding that "what element or elements are responsible....it may be considered as firmly established that after solidification all steels are composed of closely interlocked dendrites."

He (Colonel Belaiew) finds himself in complete agreement with this statement. He thinks, however, that a further step might seem warranted, as there seems to be quite sufficient data to believe that the dendritic segregation in steel is mainly caused by carbon.

In 1907 special experiments were undertaken by him to study the crystallization phenomena on pure carbon steel, that is, on steel as free from phosphorus, sulphur and oxygen as possible. The results of these experiments were published in 1908 and 1909 in Russian<sup>1</sup> and subsequently were reproduced in various papers and lectures. These results all tend to show that dendritic crystallization

1. "Crystallization of Metals," by Col. N. T. Belaiew, and previous publications.

This discussion contributed by Col. N. T. Belaiew, London, England.

was not only present in all cases, but could be revealed macroscopically in all steels, that is, in steels with different carbon content, but with very small amounts of phosphorus, from traces only in some cases, and to the maximum amount of 0.028 per cent only.

As the amount of oxygen in crucible steel is small, and as furthermore, the dendritic character of crystallization in steels is of a most general occurrence, he (Colonel Belaiew) is of the opinion that that character is to be traced neither to the particular influence of phosphorus, nor that of oxygen, nor any other impurity, but to the general character of primary solidification, as resulting from the iron-carbon equilibrium diagram.

As mentioned in his (Colonel Belaiew's) preface to his lectures on crystallization, he, when starting these researches, was animated by the idea of bringing into a closer harmony the processes of crystallization with the various areas of the diagram. He would like to add, that this desire was due in no small degrees to the influence of Professor Sauveur's work and he would like to take this opportunity to acknowledge this debt.

There is another consideration affecting the possibility or otherwise of revealing the dendritic structure, that is the fact that every dendrite, just below the solidification range, is not only a chemical "individ," but a crystallographic as well. Thence the possibility of revealing what Tschernoff used to call "the physical structure" of steel and what is dealt with, subsequently, in such a clear manner by the author on pages 31 and 32. With reference, however, to the author's question on page 29, he would like to suggest, that a reply might be given by the application of Tammann's laws of spontaneous crystallization and of the linear velocity of crystallization. His (Colonel Belaiew's) experiments have shown, for instance, that of two alloys both cooled down in the same furnace at the very slow rate of about 60 hours from 1500 to 290 degrees Cent., the hypereutectic one with 1.80 per cent carbon would show an "unigran" structure, the main dendritic axes radiating as from one center, whereas in the second alloy of hypoeutectoid steel with 0.60 per cent carbon, such centers were many and the axes, on the whole, less marked.

With reference to the granulation question he was very much impressed by the kind way in which the author was dealing with his hypothesis; he would like, however, to add, that without taking

into consideration the *delta* change, that hypothesis might seem not sufficiently clear.

He would like, further, to express his indebtedness to the author for the very considerate way in which his (Colonel Belaiew's) views on secondary crystallization and, more particularly, on the triad of secondary structures are given. He fully appreciates the author's criticism on the top of page 35 with reference to the genesis of Widmänstatten structure. He thinks, however, that the author's remarks on the foot of same page might, to a certain extent, exonerate him. He further thinks that the question of the genesis of Widmänstatten structure might be better appreciated, if taken in conjunction with that of the meteorites.

He would like also to endorse the author's plea as to the importance of "controlling" primary crystallization. Perhaps, however, his views as to the harmfulness of dendritic segregation are a little less gloomy, mainly because in his opinion this segregation is to be traced in the first instance to the carbon content, while the admixture of other elements in steels of good quality is being made as low as possible.

Finally, he would like to express his great interest in the work and in the splendid photomicrographs executed in the author's laboratory by his (the author's) pupils Messrs. Krivoboc and Smith.

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### CLOSURE

By Prof. Albert Sauveur

WE SHOULD be indebted to Professor Ellis for calling attention to the possible part played by a delta-gamma transformation in the crystallization of iron-carbon alloys. His remarks should be carefully studied.

Referring to Mr. Thum's conception of the formation of dendrites in iron and steel, I had naturally supposed that the mechanism of that formation was independent of the nature of the crystallizing substance. The arguments by which he would ascribe to them a different mode of growth are too highly speculative, I think, to justify our discarding Tschernoff's conception. Noting what Mr. Thum says about "granulation"

it will suffice to repeat that iron solidifies in the form of dendrites, generally of macro size, while when observed under the microscope it is found to consist, at room temperature, of polyhedral grains, generally of micro size. Between the solidification period and room temperature, therefore, it is apparent that the dendrites have undergone what Belaiew properly calls "granulation." There is here no obscurity in the meaning of that term. Belaiew believes that this granulation occurs while iron cools from its solidification period to its allotropic transformation. I do not claim that this has been proven, but I accept Belaiew's theory because I do not know of any other in better harmony with the observed facts. There is little profit in attempting to find merely another explanation to account for a certain phenomenon. Unless a better one can be offered, more substantially supported, we gain nothing by it.

As to dendritic segregation the existence of which cannot be denied, it is a necessary result of the mechanism of the formation of solid solution by which the constituents of lower melting points assemble in increasing proportion in the portions of the dendrites last to solidify, hence in the interstices between the axes. The fact that the etching reagent used frequently fails to disclose a "coring" effect has little significance. When the dendritic segregation is intense, the coring effect is very marked (see my Fig. 18.)

Referring to Mr. Thum's statement that a close relation exists between "dendritic segregation and fiber" it will be interesting to learn from "forgemen" whether they desire dendritic segregation for the purpose of producing fiber or for any other reason.

It is a pleasure to find myself in substantial agreement in regard to the crystallization of iron and its alloys with so distinguished a metallurgist and scientist as Colonel Belaiew. He has been a pioneer and has taught us a great deal. His theories which are the results of many years of close study and are brilliantly conceived, should not be dismissed lightly by those of us who are much less familiar than he with the phenomena involved. And what shall we say of the work of Tschernoff? Cautious and considerate criticism only is justified and helpful.

## The Question Box

A Column Devoted to the Asking, Answering and Discussing  
of Practical Questions in Heat Treatment — Members  
Submitting Answers and Discussions Are Requested  
to Refer to Serial Numbers of Questions

### NEW QUESTIONS

*QUESTION NO. 112. What quality of lead should be used  
in lead baths for heat treating steels?*

*QUESTION NO. 113. How does the use of aluminum as a  
deoxidizer affect the quality of the steel produced?*

*QUESTION NO. 114. Is it possible to obtain an accurate  
conversion table for obtaining Brinell hardness number from the  
Rockwell or scleroscope values?*

*QUESTION NO. 115. How is the fibre stress of a shaft  
calculated? Is there a relation between fibre stress and tensile  
strength and if so, can the fibre stress be estimated if the tensile  
strength is known?*

### ANSWERS TO OLD QUESTIONS

*QUESTION NO. 74. Why shouldn't a bar of steel rolled  
from a locomotive axle be better than one rolled direct from the  
billet made from the original ingot?*

**ANSWER.** One reason why a bar rolled from a locomotive axle after the axle has been in service for a long period of time, would not be better than a bar rolled directly from the ingot, is that minute fatigue cracks may exist throughout the axle, which upon exposure to the elements become oxidized. The heating of such an axle to the working temperature and subsequent rolling, will draw out these minute cracks into seams, and therefore yield a defective bar. On the other hand, if a locomotive

axle were entirely sound and free from any fissures or cracks, the steel bar rolled from it undoubtedly would have superior physical properties to a similar bar rolled directly from the ingot.

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**QUESTION NO. 83.** *In annealing high-carbon tool steel in an open-fire furnace 6 feet x 12 feet is it likely that sulphur would be imparted to the steel by the use of producer gas made from coal unusually high in sulphur, say around 1.50 to 2.00 per cent?*

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**QUESTION NO. 93.** *What are the more common methods of quenching ordinary taps? Are they quenched all over and the shanks drawn, or are they quenched only on the threaded portions; or are both the threaded portions and the tangs quenched, leaving the center portion of the shanks soft?*

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**QUESTION NO. 96.** *Can the structure of a piece of steel be determined by the microscope applied to the fracture of a cross section, without polishing and etching the fracture, say of a stamping die 6 x 2 x 3½ inches, that has been hardened and broken in half, that is, are the different structural phenomena known as austenite, martensite, sorbite, ferrite, etc., so determinable?*

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**QUESTION NO. 98.** *What heat treatment will give a pure martensite structure throughout the hardened area of a piece of steel 6 x 2 x 3½ inches?*

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**QUESTION NO. 99.** *What is the effect of barium carbonate and sodium carbonate in carburizing compounds on alloy carburizing boxes?*

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**QUESTION NO. 100.** *What action results from the addition of varying amounts of aluminum and ferrosilicon to steel while casting?*

*QUESTION 102. How can the warping of high-speed steel tools be eliminated during the hardening operation?*

ANSWER. The matter of heat treatment is one of heating and cooling in a manner suitable to the condition of the steel, and to the shape and size of the tool to be so treated. High speed steel should be annealed after machining preheated to a temperature slightly in excess of the critical range, heat brought up to the maximum temperature quickly, and after the proper time element has elapsed, cooling according to the instructions of the maker. Warping generally is due to a non-recognition of the necessity of having the steel structure in proper shape before commencing heating; to a nonsaturating preheat, or a preheat carried out too rapidly; or to improper cooling in relation to the size, shape and mass of the tool in question.

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*QUESTION 104. In the forging or ring gears, does the number of blows of the hammer have any effect upon the warpage of the gear in the hardening operation?*

ANSWER. In the case of properly forged ring gears, the number of blows with the hammer in the forging of the gear, should have no effect upon the warpings of the gear in the hardening operation, providing the gear were properly annealed subsequent to the forging operation.

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*QUESTION 105. Through what mechanism does vanadium retard the penetration of hardness in vanadium steels in the hardening operations?*

ANSWER. In straight carbon vanadium steels, the depth of penetration of hardness is greater than in simple carbon steels. This results from the fact that vanadium is primarily a carbide forming element and vanadium carbide is probably a stronger and harder carbide than simple iron carbide. Vanadium probably

exerts a similar influence on the penetration of hardness in more complex alloy steels, but instead of forming a straight vanadium carbide it undoubtedly forms carbides containing the other alloys that go to make up the steel.

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*QUESTION 106. What are the effects of the products of combustion upon both carbon and high-speed steel, when heat treated in open furnaces heated with city gas, coal, coke, fuel oil, etc?*

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*QUESTION NO. 107. In the hardening of ten thousand small tools, punches and dies weighing between three and ten pounds each what percentage loss due to hardening should be ordinarily expected?*

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**ANSWER.** Although this question can only be answered in a general way, the figures obtained in the plant of one of the large manufacturers are of considerable interest. Over a period of two consecutive months, a total of 57,024 pounds of tools were hardened with a total loss of 56 pounds. This loss represents a percentage of 0.098. The total number of pieces involved in this same comparison was 20,384, with a total of 5 pieces cracked, yielding a percentage loss of the number of pieces treated, of 0.024. These tools were used by this manufacturer in his own plant, inasmuch as this company does not manufacture tools for the market. This low percentage of loss in the hardening of tools is indeed quite remarkable, indicating that very close inspection of both incoming materials and close inspection of the heat treating processes involved in the manufacturing and tempering of these tools, was made.

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*QUESTION NO. 108. What are the advantages and disadvantages in the use of the "drop of the beam" method for determining the elastic limit of a steel tensile test bar?*

**ANSWER.** The chief advantage in the "drop of the beam" method for the determining of the so-called elastic limit, is, that it is a rapid means of determining the yield point of the specimen under test, and gives a figure for the commercial elastic limit.

The yield point is usually considerably higher than the proportional limit. The proportional limit is only obtained through a carefully plotted curve secured through the use of a delicate extensometer. This latter method determines the true elastic limit and gives a figure somewhat lower than the yield point, as determined by the drop of the beam. Probably the chief advantage in the drop of the beam method is that one operator can rapidly detect the yield point, whereas using the extensometer method, it usually requires two operators and a longer period of time to carry out the test. For commercial testing, the drop of the beam method is widely used.

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*QUESTION NO. 109. What are hairline cracks and how may they be detected?*

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*QUESTION NO. 110. Do notched bar impact specimens give more uniformly constant results than an un-notched bar?*

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*QUESTION NO. 111. How is the reduction of area of a flat tensile test specimen usually obtained?*

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#### **SHEET STEEL PAPER CORRECTED**

Due to a typographical error, the following correction to H. M. Williams' paper entitled "Sheet Steel Specifications," which appeared in the January, 1924 issue of TRANSACTIONS, is herewith made. The first sentence of the last paragraph on page 84, should read as follows: "Stretcher strains are the most undesirable defect to which all sheet steel is more or less subject."

## NOTES FROM THE U. S. BUREAU OF STANDARDS\*

## EMBRITTLEMENT OF MALLEABLE CAST IRON RESULTING FROM HEAT TREATMENT

RECENT investigations at the Bureau of Standards have shown that commercial malleable iron is often embrittled by quenching from certain temperatures in the "blue-heat" range. The low shock resistance of such material after hot-dip galvanizing has brought this fact to the front. The present study of the problem showed that the magnitude of this deterioration varied with different samples of iron, the Izod impact test being used as a convenient means for measuring the effect. The embrittlement was limited to a fairly definite range of quenching temperatures. Aging after treatment did not affect the results but the rate of cooling from the blue-heat range was important. If the malleable iron was slowly cooled instead of quenched from these temperatures, the impact resistance was much higher. It was also found that the upper limit of the embrittlement zone lay a few hundred degrees Fahr. below the critical point. Quenching from temperatures in this intervening zone increased the impact-resistance of the iron and made it immune to the blue-heat deterioration. The information obtained did not solve the question of the fundamental cause of the embrittlement but did point out a method for eliminating it.

This work is described in Technologic Paper No. 245, for sale by the Superintendent of Documents at 5 cents per copy.

## CAUSTIC EMBRITTLEMENT OF BOILER STEELS

During the past month the Bureau made a microscopic examination of a boiler plate which had developed cracks in service. Such steel is generally referred to as caustic embrittled steel. It has usually been assumed that embrittlement occurs as a result of the absorption of nascent hydrogen which has its origin in the interaction of iron and caustic alkali. The alkali results from the hydrolysis of certain "boiler additions" made to the feed water and this alkali concentrates in crevices around rivets and similar places. Cracks appear in the plate only as a result of a combination of two conditions; stress within the metal and chemical attack by the alkali. The examinations made confirm those of other investigators in showing that caustic embrittlement is an intercrystalline phenomenon, that is, the cracks have an intercrystalline course and are not directed by inclusions or other visible impurities within the steel. The examination also confirms the assumption usually made that the production of hydrogen is accompanied by oxidation of the iron. In the specimens examined all the cracks were found to be filled completely with oxide of iron, even to the innermost ends of the finest microscopic cracks, where the chance of oxidation from without would be entirely negligible.

\*Information Obtained from Technical News Bulletin No. 81. Published by the Department of Commerce, Bureau of Standards, Washington.

## HARDNESS CHANGES ACCOMPANYING THE SEVERE COLD WORKING OF METALS

By referring to past numbers of the bulletin it will be seen that for some time the Bureau has been investigating the changes in hardness which accompany the severe cold working of metals. At the recent meeting of the advisory committee on nonferrous metals several suggestions were made for further work on this problem and during the past month several of these suggestions were followed out. The results obtained indicate that the hardness changes of metals after severe cold working, as measured on the surface of cold rolled strips, are of the same nature as the changes within the strips, that is, as measured on sections through the strips perpendicular to the surface. There do not appear to be any pronounced directional properties in the hardness of severely cold rolled metals. The effect of the temperature of rolling on zinc and copper also was investigated. When the rolling was carried out at rather low temperature, produced by cooling both the rolls and the specimen with ice water, it was found that the hardening of the metal, particularly of the zinc, during the initial stages of deformation, was greatly increased. The tendency of the metal to crack and split during the initial stages of deformation was very marked. After the metal had been reduced into a strip, however, softening occurred as before, and with further deformation the low temperature appeared to have but little if any influence.

## DEFECTS IN PHOSPHOR BRONZE

A considerable amount of work has been done recently on the metallographic examination of a series of phosphor bronzes submitted to the Bureau by a manufacturer of this type of material. The specimens failed to cold roll satisfactorily as they showed pronounced cracks which occurred during the rolling. The examination showed the cause to lie in the presence of oxide within the metal and indicated that the mere addition of phosphor copper to such a bronze does not give assurance that deoxidation has resulted. Stannic oxide can exist within such an alloy in spite of the addition of phosphor. Chemical analyses confirm these conclusions by showing the absence of other substances which might, if present, contribute to the brittleness of the bronze. The remedy for this condition must be applied in the foundry during the melting operation, that is, the phosphor additions to the alloy must be made before there is any chance for stannic oxide to form.

## NEW STANDARD SAMPLES OF PHOSPHATE ROCK AND MANGANESE BRONZE

Two new standard samples are now ready for distribution with provisional certificates. These are Phosphate Rock Sample No. 56 and Manganese Bronze Sample No. 62.

One other sample is still on the lathes and seven are in the hands of the co-operating analysts. Four hundred and forty-eight samples were sent out during the past month.

## NOTES FROM THE U. S. BUREAU OF MINES\*

## SILICA STUDIES

IN THE course of the investigation of technical problems pertaining to silica, being conducted by the Department of the Interior, through the Bureau of Mines, a number of silica preparation and sand mining and preparation plants in New Jersey have been visited. A study was made of methods employed in the calcining, grinding and pulverizing of flint, quartz and silica sand; mining, handling, blending and loading of molding sand; mining, washing and special cleaning of glass sand; and washing, screening and handling of sand blast and filter sand. The Bureau of Mines has received valuable data from producers of various silica products. Study has been given to the needs of consumers using sand-blast sand, chemical and metallurgical quartz, filter sand, and glass sand.

## EXPANSION OF FIRE-CLAYS

The purpose of an investigation being undertaken by the Department of the Interior at the Ceramic Experiment station of the Bureau of Mines, Columbus, O., is to determine the use of the expansion which certain fire clay ware exhibit when subjected to certain heat treatment. Lack of information on this subject has greatly hampered the testing of certain fire clay bricks under load as well as the control of the commercial burning of the ware.

The mode of attack was outlined in conference with several authorities who convened at Columbus for the purpose. The co-operation of three manufacturers of flint fire clay brick, who furnished samples of their clays for use in the investigation, has been obtained. Information has been obtained, by correspondence, from the leading men in the industry and from testing laboratories through the country. The literature is being searched and abstracted. Some preliminary microscopic examinations of the crude clays and the finished products have been made.

## OPEN-HEARTH REFRactory MATERIALS

In connection with the study of open-hearth refractory materials, being undertaken by the Department of the Interior at the Ceramic Experiment station of the Bureau of Mines, Columbus, O., experimental work has been started which has as its aim the production of a high alumina refractory using a kaolinitic bauxite as the raw material. There are large deposits of bauxite high in silica, that have found a very limited field of usefulness, which it is hoped can be utilized to produce a less acid refractory than silica and which will at the same time have a higher fusion temperature. When such material is fused or highly

\*Information Obtained from the January, 1924, Press Memorandum of the Department of the Interior, Bureau of Mines, Washington.

sintered, it can be made into a brick which will be practically free from the high shrinkage characteristic of bauxite brick burned at the ordinary kiln temperatures. The mineralogical composition aimed at is a mixture of sillimanite and corundum together with the eutectic formed between these two minerals.

It is proposed to prepare the sinter by the method proposed by Lecesne or whatever modification of same may seem desirable. One modification which has been suggested is the utilization of oxygen-enriched air for the blow toward the end of the burn.

A study of the possibility of increasing the proportion of tridymite in a silica brick by the utilization of a suitable flux to aid in the normally sluggish transition from quartz to tridymite, has been started. To just what extent this transition is possible by holding commercial bricks within the tridymite range for varying lengths of time up to two weeks, is under investigation.

#### REMOVAL OF PEBBLES FROM CLAYS

A study of the removal of pebbles from clays used in the manufacture of heavy clay products is being made by the Department of the Interior, through the Bureau of Mines. The first work undertaken in this problem consists of a survey of the methods employed and proposed for the removal of pebbles from surface clays. Clay manufacturing plants have been visited for the purpose of observing methods used in separating pebbles. A number of untried methods for the cleaning of such clays will be studied by the Bureau of Mines. This work is being performed at the Ceramic Experiment station, Columbus, O., in co-operation with Ohio State university.

#### ELECTRICAL CONDUCTIVITY OF REFRactories

In the general study of the electrical conductivity of refractories, being conducted by the Department of the Interior at the Columbus, O., experiment station of the Bureau of Mines, tests have been completed on Maryland, Indian and Italian talcs from 500 degrees Cent. to and including 1000 degrees Cent. These talcs at the present time are being used for the manufacture of electrical insulators and cores for electrical heating appliances. Since 1000 degrees Cent. represents the maximum temperature at which these talcs are burned and used, tests were not carried to a higher temperature. Preliminary tests have been made on diaspore and magnesite.

## Comment and Discussion

Papers and Articles Presented Before the Society and Published in Transactions Are Open to Comment and Criticism in This Column—Members Submitting Discussions Are Requested to Give Their Names and Addresses

### DISCUSSION OF PAPER ENTITLED "SALT BATHS AND CONTAINERS FOR HARDENING"

THE following letter in discussion of Mr. Tour's paper as published on page 7 of the January, 1924 issue of TRANSACTIONS was recently received.

January 17, 1924

To THE EDITOR:

We refrained from discussing Mr. Tour's paper on salt baths when it was presented at the fifth annual convention of the society, chiefly because we are in the salt bath business and we did not want to take commercial advantage of our connection with the society.

However, in order to correct some very widespread misapprehensions of the present development of liquid heating baths, I think it is important that you publish the following statements, particularly in view of the fact that many members of the society must depend on the information they get from TRANSACTIONS as being the last word on the subject.

We have developed salt baths that can be used for heating steel to all temperatures up to its melting point without any decarburizing effect on the steel, without any deterioration of the salt bath material itself, or without any attack of the steel pots. We demonstrated these results at the convention and give a standing invitation to anyone, and especially to those who say "it can't be done," to bring or send us, any size sample of any grade of steel, at any time, to heat to any temperature, to prove these facts. Tons of this material are manufactured and used every month.

Assuring you of our hearty support of all your good efforts to promote the fascinating fine art of heat treating, we are

Very truly yours,

THE BELLIS HEAT TREATING CO.

(Signed) A. E. BELLIS, President.

## Abstracts of Technical Articles

### Brief Reviews of Publications of Interest to Metallurgists and Steel Treaters

**CHEMISTRY IN SEMI-STEEL.** By J. E. Bock in *Iron Age*, Vol. 112, page 397 (1923).

This article outlines the duties of a foundry chemist. The analyses necessary in a foundry laboratory are discussed. Certain facts concerning the effect of carbon, manganese, sulphur, phosphorus and silicon are given.

**GEAR TOOTH GRINDING.** By Franklin D. Jones in *Machinery*, October, 1923, page 85.

In this article the author discusses the various methods and machines used for this process. The article is well illustrated.

**ECONOMICAL USE OF FUEL IN STEEL PLANTS.** By H. E. Siebert, combustion engineer, Bethlehem Steel company, Bethlehem, Pa., in *Iron Age*, December 20, 1923, page 1651.

The above is an abstract of an article read before the Association of Iron and Steel Electrical Engineers at Buffalo and tells of a possible way to save more than forty million dollars annually by having the proper design, construction and operation.

**NOTES ON THE SELECTION OF A COPPER-SMELTING PLANT.** By W. A. Heywood, in *Bulletin of Institute of Mining and Metallurgy*, No. 223, (1923).

The author of this article discusses plant design from the standpoint of the type of ore, size and costs. Reverberatory smelting is favored over blast-furnace only where a large part of the ore is finely divided, or where coal or oil is much cheaper than coke, or where water is scarce.

**ON DEFECTIVE PORTION IN ALLOYED STEEL.** By A. Schleicher in *Stahl und Eisen* No. 47, page 1449 (1923).

The above article proves that the fractures in alloyed steel known as "folks" are there in accordance with the presence of included stationary oxidized slag. It also proves that these oxidized enclosures are concentrated due to a bad reduction.

ELECTRIC FURNACE REFRACTORIES. By R. C. Gosrow, metallurgical engineer, Chicago, in *Chemical and Metallurgical Engineering*, Dec. 31, 1923, page 1181.

The above article gives a number of practical suggestions for the construction of lining walls, hearths and roofs of electric furnaces, thus enabling the electric furnace operator to obtain maximum refractory service.

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IMPORTANCE OF DISSOCIATION OF CHEMICAL COMPOUNDS IN STEEL MAKING. By J. Kent Smith, consulting metallurgist, Sheffield, England, in *Chemical and Metallurgical Engineering*, Jan. 14, 1924, page 49.

This article gives a number of observations on the use of carbonless alloys for introducing the alloying metal into steel, which shows the significance of chemical dissociation to metallurgists.

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MOLYBDENUM IN CAST STEEL AND IRON ROLLS. By W. Norman Bratton, sales metallurgist, Climax Molybdenum Co., New York City, in *Iron Age*, Dec. 6, 1923, page 1509.

The author discusses the heat treatment and wearing qualities of low-carbon steel rolls and alloy iron rolls. Some of the properties of molybdenum are also given.

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DEVELOPMENT OF MODERN STAMPING PRACTICE. By W. W. Galbreath and John R. Winter, president and general superintendent, Youngstown Pressed Steel Co. in *American Machinist*, Dec. 13, 1923, page 883.

The above is an abstract of a paper presented before the machine shop division of the American Society of Mechanical Engineers, at their annual meeting, Dec. 3 to 6, 1923. It discusses the early uses of pressed metal and pressed steel in the automobile field; the use of pressed steel in place of cast iron parts and the various other applications of pressed steel.

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CASTING HIGH SPEED STEEL TOOLS. By J. M. Quinn, in *Iron Trade Review*, Jan. 17, 1924, page 226.

The above article discusses the methods of manufacturing high speed steel tools cast to an approximate size and shape as well as discussing the manner in which the properties of these tools can be controlled.

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HOW TO IDENTIFY NICKEL AND STEEL AT BINS. By H. C. Knerr, metallurgist, Naval Aircraft Factory, Philadelphia, in *Automotive Industry*, Dec. 20, 1923, page 1253.

The author gives a simple test for distinguishing nickel steels from steels containing no nickel. The test is so simple that it can be performed in a few seconds by an ordinary operator.

## Reviews of Recent Patents

By

NELSON LITTELL, Patent Attorney  
110 E. 42nd St., New York City

**1,461,555. Cast Metal Annealing Box.** Emil C. Raschenberg of Wheeling, W. Va., assignor to Wheeling Mold & Foundry Co., of Wheeling W. Va.

This patent describes a cast metal annealing box, particularly designed for annealing sheet plate, which consists of integral sides, ends, and top, of uniform thickness, except for the thickened base rim upon which the box rests when in use. To strengthen the box against sagging and to prevent cracking due to expansion and contraction, a plurality of corrugations spaced some distance apart, extend up one side, across the top and down the other side. Across the top the corrugations are deeper than on the sides so as to give extra strength to the top. A single corrugation extends up each end of the box and the corners are rounded to permit expansion and contraction of the ends.

**1,462,639. Steel-heating Furnace.** James Hundley of Noblesville, Ind., assignor to New Process Iron and Steel Co. of Noblesville, Ind.

This patent discloses a furnace consisting of a combustion chamber and a heating chamber separated by suitable baffles. A pair of endless conveyors located one above the other travel in opposite directions through the heating chamber, and a third conveyor near the combustion chamber receives the heated articles which have been carried through the heating chamber by the upper endless conveyor and carries them out of the furnace. The article carrying conveyor is provided with a trough through which slag or other fused material may be carried out of the furnace. The lower conveyor carries out any ash or other debris or any of the articles which may drop from the upper conveyor.

**1,463,228. Method of manufacturing Wrought Iron.** Albert Sauveur, of Cambridge, Mass.

This patent describes a method of making wrought iron by a continuation of the ordinary Bessemer process. A side blown Bessemer converter with the discharge opening and the wind box located on the same side and a transverse weir about midway of the opposite side is used. The molten pig iron is introduced into the converter and blown as in the ordinary Bessemer process, and slag or other oxidizing substance is then introduced and fused with the iron or mild steel resulting

from the blow. The converter is then tilted with the weir side down and rocked back and forth to cascade the iron and slag back and forth over the weir so as to distribute the slag through the iron. When the charge has become pasty, it is dumped from the converter onto a conveyor and taken to a squeezer or hammer where the "puddle ball" is worked as in the usual wrought iron practice to squeeze out the slag.

**1,463,438. Carbonizing Furnace. Nels Olsen, San Leandro, Cal.**

This invention is intended to provide a furnace for uniformly heating a stationary carbonizing retort. The furnace consists of a vertical cylindrical refractory lined heating chamber and a concentric cylindrical retort on the inside thereof and spaced from the walls of the heating chamber. The fuel is introduced into the space between the retort and the heating chamber by a plurality of uniformly spaced pressure nozzles which direct the flame tangentially around the retort so as to uniformly heat the same. The ends of the heating chamber and of the retort are closed, and the retort is provided with a removable cover whereby the articles to be carbonized may be inserted in and removed from the same. The carbonizing medium consisting, preferably, of illuminating gas is introduced into the retort through a pipe in the bottom thereof and escapes through a vent in the cover.

**1,463,609. Casting Oxidizable Metals. Adolf Beck and Karl Gersbach of Bitterfeld, and Oskar H. Weber of Griesheim-on-the-Main, Germany, assignors to Chemische Fabrik Griesheim-Elektron, Frankfort-on-the-Main, Germany.**

This patent relates to a method of casting magnesium or other easily oxidizable metals or alloys. When these metals are cast in sand molds the access of air to the casting before the metal has cooled below its oxidizing temperature often ignites the casting and burns portions of its surface rendering the casting worthless. The inventors have found that the use of a suitable mold coating, which at the casting temperature of the metal will give off gases more easily oxidizable than the cast metal, will prevent oxidization of the casting. For example, magnesium oxalate when dried is blown in a fine powder onto the surface of a dry sand mold, or is applied as a wash. The cast metal decomposes the coating into magnesia, which remains on the surface of the sand and carbon monoxide with carbonic acid which when forming prevent the air from gaining access to the metal in the mold. Pulverized sulphur when blown onto the mold will also protect the castings from oxidization.

**1,463,771. Means to Compress Ingots. Alvin A. Claassen, of Chicago, Ill.**

This patent proposes to reduce the pipe in an ingot by compressing

the top of the ingot after the outer skin of the same has become solid. The apparatus consists of an ordinary ingot mold provided with rectangular cast steel compression bars of substantially less width than the width of the ingot, and which extend from the top, about one-half of the way to the bottom of each side of the mold. Between each bar and the wall of the mold a wedge is inserted. During the pouring operation the compression bars are held firmly against the side of the mold by means of integral pins which project out through the walls of the mold and are secured outside the mold by means of wedge keys. When the skin of the ingot has solidified, the wedge keys are released and the compression bars forced inward to compress the top of the ingot by driving down the wedges between the compression bars and the mold walls. The wedges are shaped so as to give the greatest amount of compression at the top of the ingot.

**1,464,174. Air-hardening Steel Alloy.** William F. Finkl, of Chicago, Ill., assignor to A. Finkl & Sons Co., a corporation of Illinois.

This patent describes a new alloy steel containing nickel chromium and molybdenum in varying proportions within a limiting range of 0.50 to 2.00 per cent nickel, 0.25 to 1.10 per cent chromium, 0.15 to 2.00 per cent molybdenum, and 0.30 to 1.10 per cent carbon. According to the inventor, this alloy is capable of being hardened sufficiently for all practical purposes by cooling in air from a wide range of hardening temperatures. When in an annealed condition, it may be readily machined. A preferred composition of the alloy is carbon 0.50 to 0.85 per cent chromium 0.40 to 0.95 per cent, molybdenum 0.30 to 0.80 per cent, and nickel between 0.50 to 2.00 per cent according to the degree of toughness desired. The alloy is especially recommended for machine parts of irregular shape or with relatively heavy and light portions as they may be readily machined in an annealed condition and may be safely air-hardened without appreciable warping, shrinking or cracking.

**1,464,543. Electric Furnace.** Marius Savoageon of Paris, France.

This invention relates to an electric furnace adapted to heat by radiation either from the crown of the furnace or from the sides or both. The patent discloses a furnace the walls or crown of which is composed of a number of compartments, the walls of which are good conductors of heat and at high temperatures are also good conductors of electricity. The compartments are filled with granular resistance material through which the current is passed to heat the walls and radiate the heat into the furnace. Each compartment is preferably provided with an opening through which the amount of granular material may be ascertained and the supply replenished when necessary.

**1,464,634. Process for the Production of Basic Steel.** Rene Bauret of Paris, France, Assignor to La Societe: Usines Metallurgeques De La Basse, Loire, Paris, France.

This patent discloses a process of producing in a basic converter, hard or semihard steels, of high carbon content, and totally dephosphorized, without adding spiegeleisen, pig iron or other recarburizing agents. The inventor has discovered that the presence, in a basic converter, of a calcareous slag rich in oxides of iron will dephosphorize the newly charged pig iron very rapidly so that substantially complete removal of the phosphorus may be had before the carbon is entirely oxidized, and that by taking proper precautions as to the proportions of pig iron added it is easy to obtain steels showing the analysis, carbon 0.50 to 0.60 per cent with a content of 0.05 per cent phosphorus without recarburizing.

**1,464,862. Method and Apparatus Relating to the Production of Metals.** Clarence W. Balke, of Highland Park, Illinois, Assignor to Fansteel Products Company, Inc. of North Chicago, Illinois.

This patent discloses a process and apparatus for producing metals which oxidize readily at temperatures approximately their melting points, and deals more especially with the production of misch metal (cerium and certain other rare metals combined with a small percentage of iron). The metal is produced in the usual manner by the electrolysis of cerium chloride using a cast iron pot as a cathode and a graphite or carbon electrode for the anode. During the electrolysis the misch metal collects at the bottom of the pot and the fused salt floats on top and prevents oxidization of the metal. In order to remove the misch metal from the pot when sufficient has been produced, without removing the pot or without oxidizing the metal, the inventor provides a means for preventing radiation from the crucible, and raises the temperature thereof to the melting point of the metal, then draws the metal through a pipe from beneath the fused salt bath into a suitable mold by means of a vacuum pump. When sufficient of the formed metal has been withdrawn the crucible may be permitted to cool down again to the most efficient operating temperature and the electrolysis of the salt continued. By this method the metal may be withdrawn without interrupting the current to that particular pot so that a plurality of furnaces may be operated in series without having to stop all the furnaces to withdraw the metal from one.

**1,465,927. Hardness Testing Device.** Richard Baumann of Stuttgart, Germany.

This patent shows a hardness testing device consisting of a pair of telescoping cylinders, the lower one of which supports a ball which is adapted to be forced into the material being tested. A plunger de-

pends from the top of the other cylinder and on it is a weight, or hammer propelled downwardly by a coil spring. When the ball is placed against the material to be tested and the upper cylinder pushed downward on the lower cylinder, cam triggers in the lower cylinder prevent the weight or hammer from being pushed down so that the spring is compressed between the weight and the top of the upper cylinder until at a predetermined point the cam triggers are released and the weight or hammer is projected with a measured force against the lower end of the bottom cylinder to force the ball into the material, the depth of the depression made by the ball being a measure of the hardness of the material. The plunger keeps the weight or hammer centered in the cylinder and guides its descent toward the work.

**1,465,941. Machine for Granulating Metal Turnings or Borings.**  
**Elwin K. Hill of Cleveland, Ohio.**

This machine is designed for granulating lathe turnings, borings or the like whereby they may be more economically compressed into blocks or billets for remelting. The machine is of a sausage mill type in which two parallel worm conveyors are used to force the turnings through the cylinders. Means are provided for forcing the turnings into the feed of the worms, and at the extruding end, the conveyors carry a plurality of knives for shearing the borings. The cylinder walls are provided with replaceable liners so that the wear thereon may be taken up and the knives are detachable so that they may be readily removed for sharpening.

**1,466,301. Process for Producing Steel.** John T. Jones of Pittsburgh, Pa., Assignor to Howells Metallurgical Company of Pittsburgh, Pa.

This invention proposes to use molten pig iron containing a high percentage of combined carbon (when cold?) as a deoxidizing and recarburizing material in the Bessemer or open-hearth converter. It also discloses and claims a process of carburizing and hardening the surface of iron or steel articles by immersing them in molten, white charcoal pig iron for a short time.

**1,466,636. Treatment of Manganese Steel Castings.** Stanley Apgar and George R. Hanks of High Bridge, New Jersey, Assignors to the Taylor-Wharton Iron and Steel Company of High Bridge, N. J.

The object of this invention is to provide a dependable method of heat treating manganese steel castings of large size and intricate section, and especially for casting of from eight to twenty tons weight. The casting is permitted to remain in the mold until it can be handled without bending. The large surface areas are enveloped in a sand blanket to prevent radiation and the casting is then placed in a furnace

heated to 500 degrees Cent. and the furnace is sealed and held without firing until the furnace and casting are at an even temperature, whereupon the heat is slowly dispersed and the sand blanket removed after which the casting is heated to the usual temperature for treating manganese steel and quenched in water.

**1,467,112. Process of Making Molds.** Theopheiles D. Lucier of Detroit, Mich.

This patent discloses a process of making permanent molds for the casting of high melting point metals and alloys which comprises shaping a plastic mixture of graphite and coal tar or pitch, to the desired shape, packing the shaped material in fine carborundum or other refractory and heating in an oven to about 1600 degrees Fahr. to carbonize the tar or pitch binder, after which the carbon derived from the tar or pitch may be converted into graphite by placing the carbonized mold loosely packed in carborundum between the contact points of an electric furnace, and using sufficient current to convert the carbon into graphite.

**1,467,236. Superheating Furnace Especially for Rotary-Cast Pipe.** Dimitri Sensand de Lavand of New York, N. Y.

This invention relates to a furnace, especially designed for heat treating centrifugal cast iron pipe which are cast with a chill so as to convert the chilled white iron into soft gray iron. The apparatus comprises a short substantially circular oil fired furnace, open at each end, with means for progressively feeding the centrifugally cast iron pipes through the furnace and for rotating them while in the furnace so that all parts of the pipe which are in the furnace may be uniformly heated.

**1,467,042. Method of Producing Pipe Balls.** John H. Hall of High Bridge, N. J., Assignor to Taylor-Wharton Iron and Steel Company, of High Bridge, N. J.

This patent criticizes the prior practice of producing manganese steel pipe balls by pouring the same hot, on the ground that this permits the crystals to dispose themselves in columns at right angles to the surface of ball, which causes an inherently weak crystalline structure. The prior defects are overcome according to the patent by pouring the steel close to its freezing point whereby a uniformly fine grain structure is produced free from columnar crystals. The balls are then charged in small lots into a furnace heated to at least 800 degrees Cent., the temperature is then elevated to about 1060 degrees Cent. and after remaining at that temperature twenty-five to forty minutes the balls are quenched in water.

## News of the Chapters

### SCHEDULED REGULAR MEETING NIGHTS

FOR the convenience of visiting members, those chapters having regular meeting nights are listed below. It is desired that all secretaries whose chapters are not included in the list communicate with the National office in order that the list may be as complete as possible.

Boston—Third Thursday.

Cleveland—Fourth Friday, Cleveland Engineering Society rooms, Hotel Winton; meeting at 8 p. m.

Chicago—Second Thursday.

Hartford—Tuesday nearest 10th of month.

New Haven—Third Friday.

New York—Third Wednesday, assembly room, Merchants Association of New York, ninth floor, Woolworth building.

Philadelphia—Last Friday, Engineers' club.

Tri City—Third Thursday.

### BUFFALO CHAPTER

THE Buffalo chapter of the American Society for Steel Treating held their regular meeting on Jan. 11 at Hotel Buffalo. The program for the evening included three papers being presented. The first presentation was given by R. E. Sherlock, metallurgist, Donner Steel Co., Buffalo, on the application of alloying elements in special steels, especially chrome, molybdenum, vanadium and nickel. Ernest Anderson, Crescent Tool Co., Jamestown, N. Y. presented the second paper which was entitled, "The Hardening of Carbon and Chrome Nickel Die Blocks." The third paper entitled, "The Welding and Heat Treating of High Speed Steels" was given by F. G. Brost, Lancaster Machine & Knife Co., Lancaster, N. Y. This meeting was very interesting and instructive. Dinner was served at 6:30 preceding the meeting.

### CHICAGO CHAPTER

The Chicago chapter of the American Society for Steel Treating held their January meeting on the tenth of the month at the City club at 8:00 p.m. A. H. d'Arcambal, metallurgist, Pratt & Whitney Co., Hartford, addressed the chapter with an illustrated paper on "Carbon Tool and High Speed Steels Used in the Manufacture of Small Tools." This was the best attended meeting the chapter has had, there being 132 present for dinner, 18 of which were from Pratt & Whitney. Mr. d'Arcambal who has a national reputation gave a very capable presentation which brought forth much interesting discussion.

**CINCINNATI CHAPTER**

The Cincinnati chapter of the American Society for Steel Treating at their Jan. 10 meeting held at Ohio Mechanics institute, was addressed by Prof. H. M. Boylston, professor of metallurgy, Case School of Applied Science, Cleveland, who chose for his subject, "The Microscope as Applied to Steel Treating." A lively discussion followed this presentation which proved to be very instructive.

**CLEVELAND CHAPTER**

On Friday, Jan. 28, the Cleveland chapter of the American Society for Steel Treating held a meeting in the Cleveland Engineering society rooms, Hotel Winton, at 8:00 p.m. The speaker of the evening was Dr. W. S. Carnes, Canton Cutlery Co., Canton, O., who spoke on the development of the cutlery industry. He likewise demonstrated a steel which he developed and uses in the manufacture of his pocket knives. Dr. Carnes' address was very well delivered and brought forth much interesting discussion.

**DETROIT CHAPTER**

On Monday, Jan. 21, 1924, the Detroit chapter of the American Society for Steel Treating held their January meeting in the General Motors building. Bureau of Mines motion picture films giving the various methods used in the manufacture of carbon and alloy steels were shown. These pictures explain clearly the various operations in steel manufacture in a very interesting manner. Dinner was served at 6:30 p.m. preceding the meeting.

**HARTFORD CHAPTER**

The Hartford chapter of the American Society for Steel Treating held their January meeting on the eighth of the month in the Hartford Electric Light Co. building. The speaker of the evening was R. J. Allen, metallurgist, Rolls-Royce Company of America, Springfield, Mass., who chose for his subject: "The Inspection of Steels Used in Automotive Construction." Mr. Allen has had a number of years of interesting experience and gave a very capable presentation. Much discussion followed the paper. Dinner was served at the Hotel Garde at 6:30 p.m.

**INDIANAPOLIS CHAPTER**

On Monday evening, Jan. 14, the Indianapolis chapter of the American Society for Steel Treating held their regular meeting at the Y. M. C. A. The program for the evening included an interesting presentation by Frederick W. Krebs, sales engineer, United Alloy Steel Corp., Canton, O., on "Alloy Steel—Rolling, Annealing and

"Cold Drawing." The speaker's long experience in the production of alloy steels and his intimacy with present day mill practice, gave him the opportunity to present his paper in a very capable manner. After this presentation, Harry Thompson explained and demonstrated the use of a new gear inspection instrument, the Odontometer. Dinner was served at 6:30 p.m. preceding the meeting.

### LEHIGH VALLEY CHAPTER

The Lehigh Valley chapter of the American Society for Steel Treating held a meeting on Friday evening, Jan. 25 at the Battery building of the Bethlehem Steel Co. George E. Thackray special engineer, Bethlehem Steel Co. addressed the chapter on "A Few Historical Notes on Iron and Steel." This was a very interesting presentation.

### LOS ANGELES CHAPTER

The December meeting of the Los Angeles chapter of the American Society for Steel Treating was held on the twelfth at the offices of the Westinghouse Electric & Manufacturing Co., 418 South San Pedro street. The speaker of the evening was Harry S. Cooper, consulting metallurgist, and formerly of Cleveland. His subject was entitled "Subsequent Treatment of Carburized Steel." Mr. Cooper presented interesting samples, illustrating various treatments, which were of considerable interest to all of the members.

The chapter held their January meeting on the eighth of the month at the same meeting place. The subject of the evening entitled, "Pyrometers and Thermometers" was presented by W. H. Laury, who was formerly a member of the subcommittee on pyrometry of the standards committee of the society. Mr. Laury gave a very capable presentation discussing the use and application of pyrometers. An interesting discussion followed Mr. Laury's paper.

### MILWAUKEE CHAPTER

The December meeting of the Milwaukee chapter was held at the Hotel Blatz, Friday, Dec. 14, 1923. Dinner at 6:30 p.m. preceded the meeting which was held at 8:00 p.m.

E. W. Ehn, metallurgist of the Timken Roller Bearing Co., Canton, O., was the speaker of the evening. Most members of the society who have had the opportunity of hearing Mr. Ehn's interesting lecture on the difficulties encountered in carburizing and hardening did not miss the chance to hear this educational and valuable paper again. The paper covered every phase of the carburizing and hardening operation, from equipment to finished product and was augmented by some very worthy microphotographs dealing with the subject.

A very interesting and instructive discussion followed the paper

and the Milwaukee members and guests are well assured of other talks, that are scheduled for the remainder of the year, that will also answer some of the vague points in their minds on the various subjects presented.

The Milwaukee chapter of the American Society for Steel Treating held a meeting at Hotel Blatz on Tuesday evening, Jan 29 at 8 p. m. A. W. Lorenz, metallurgist, Bucyrus Co., spoke to those in attendance on the subject of "Steel Castings." This was a very capable presentation and brought forth much valuable and instructive discussion. Dinner was served at 6:30 p. m. preceding the meeting.

#### NORTH WEST CHAPTER

The North West chapter of the American Society for Steel Treating held a meeting on Jan. 22 at 8:00 p.m. at the Manufacturers' club, Minneapolis. A round table discussion upon several subjects was held, which proved of great benefit, inasmuch as those in attendance presented problems for which solutions were given.

The University of Minnesota, through its extension division, offers a course in "Metallography and the Heat Treatment of Iron and Steel." The course will be conducted by Dr. O. E. Harder, and will begin on Monday, Jan. 28 at 7:30 p.m. at the School of Mines building at the university, and will continue each week for sixteen weeks, two hours an evening. The general policy of the course will be to make it of the greatest possible use to the men who enroll. It will cover methods used in determining the proper heat treatment of iron and steel, and the way in which they may be controlled. It will also include examination of specimens which have failed in service because of improper treatment, the manner of determining the cause of such failure and the suggestion of the proper practice. Theoretical discussion will be limited to only what is necessary for a proper understanding of the methods of heat treatment and the solution of various problems. The lectures will be supplemented by laboratory demonstrations and a certain amount of laboratory work, so that the information acquired, may be applied practically to the daily work of the members. A discussion of actual problems which the men have met in their own plant work will be included, and any member of the class may bring up his problems for discussion and solution. This course will be of benefit to all those engaged in actual heat treating, including those employed in foundries, machine shops, engineers, etc. It will be an exceptional opportunity to obtain useful scientific knowledge which can be practically applied. Further information may be obtained by communicating with Dr. O. E. Harder, University of Minnesota, Minneapolis, Minn.

#### PHILADELPHIA CHAPTER

On Jan. 4, 1924, the Philadelphia chapter of the American Society for Steel Treating held their regular meeting at the Engineers' club,

at which time W. M. Mitchell, metallurgical engineer, E. I. DuPont deNemours & Co., Wilmington, Del., gave an illustrated paper entitled, "Chromium, the Metal, Its Alloys and Uses." A practical illustrated talk entitled, "The Grinding of Steel" was given by R. A. Cole, engineer, Norton Co., Worcester, Mass. Much interesting and instructive discussion was brought forth after the presentation of these papers. Dinner was served at 6:45 p.m. in the club dining room.

On Jan. 25 at 8:00 p.m. the Philadelphia chapter of the American Society for Steel Treating held their meeting at the Engineers' club. Dr. Ancel St. John, Union Carbide & Carbon Research Laboratories, Inc., Long Island City, gave an illustrated lecture on "X-Ray Examination of Metals." Dr. St. John showed how remarkable results have recently come to light with the use of the X-ray, in diagnosing certain imperfections of metal parts. He further stated that the X-ray has proved its ability in locating small flaws in the interior of steel parts several inches thick, and has given a clearer understanding of the atomic structure of metals and their heat treatment. A description of the practical applications of the X-ray in improving steel parts, was also given. "Tool Steel Experiences" was the title of a practical talk given by G. Peterson, Atlas Steel Corp., who has had wide experience on this subject. Very valuable discussion was brought forth following the presentation of these papers.

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### PITTSBURGH CHAPTER

The Pittsburgh chapter of the American Society for Steel Treating held their regular monthly meeting Tuesday, Jan. 29 at 8:00 p.m. in the crystal parlor of the Wm. Penn hotel. The paper of the evening entitled, "Molybdenum Metal and Molybdenum Steels," was presented by John D. Cutter, vice president and metallurgist, Climax Molybdenum Co., New York City, who is an expert and specialist on the general subject of molybdenum steel and its heat treatment. An interesting discussion ensued. Dinner was served in the cafeteria at 6:30 p.m. preceding the meeting.

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### RHODE ISLAND CHAPTER

On Wednesday, Jan. 23 at 8:00 p.m. in the rooms of the Providence Engineering society, T. Y. Olsen, president, Tinius Olsen Testing Machine Co., Philadelphia, addressed the Rhode Island chapter of the American Society for Steel Treating, on "Testing Machines and Their Use." Mr. Olsen is an authority on testing steel, and his presentation was very interesting and instructive, bringing forth much valuable discussion.

**ROCHESTER CHAPTER**

The Winter Sectional meeting of the Society was held under the auspices of the Rochester chapter of the American Society for Steel Treating on Jan. 31 and Feb. 1, and inasmuch as the February issue of TRANSACTIONS went to press on the eve of this meeting, a full report of the meeting will be given in the March issue of TRANSACTIONS.

**SOUTH BEND CHAPTER**

The South Bend chapter of the American Society for Steel Treating held a meeting on Jan. 23 at the South Bend Y. M. C. A. at 7:45 p.m. E. C. Smith, chief metallurgical engineer, Central Steel Co. addressed the chapter on "Alloying Material in the Manufacture of Steel." This paper was very capably presented and brought forth much discussion. W. C. Happ, Studebaker Corp. also spoke to those in attendance on the subject of "Budgetary Control of Manufacturing." The meeting was very well attended.

**SPRINGFIELD CHAPTER**

On Tuesday evening, Jan. 29 at 8 p. m. the Springfield chapter of the American Society for Steel Treating, held a meeting at the Chamber of Commerce rooms. E. A. Sanford, metallurgist, Indian Motorcycle Co., Springfield, Mass., addressed the chapter, speaking of some of the troubles encountered in the machining and heat-treating of the materials used in the manufacture of the motorcycle and the methods used to overcome them. A lively discussion followed this presentation. A get-together dinner meeting was held prior to the regular meeting at the Highland hotel at 6:30 p. m.

**SYRACUSE CHAPTER**

The Syracuse chapter of the American Society for Steel Treating held a meeting on Monday, Jan. 21 at the Yates hotel at which time John H. Nelson, Wyman-Gordon Co., Worcester, Mass., gave an illustrated talk entitled, "Drop Forgings." An interesting and instructive discussion followed the presentation.

**TORONTO CHAPTER**

The Toronto chapter of the American Society for Steel Treating held their January meeting in the Day building, on Friday, Jan. 25 at 8:15 p. m. T. Holland Nelson, Cyclops Steel Co., Titusville, Pa., was the speaker of the evening, choosing for his subject, "High Grade Tool Steel from Ingot to Finished Bar," which was illustrated with lantern slides. Considerable discussion was brought forth following this presentation.

**TRI CITY CHAPTER**

The Tri City chapter of the American Society for Steel Treating held a meeting on Jan. 17 at 8:00 p.m. at the LeClaire hotel, Moline, Ill. The speaker of the evening, Edwin T. Jackman, Firth-Sterling Steel Co., Chicago, gave a very interesting address on "Stainless Steel." This paper was very well received and brought forth much valuable discussion. Mr. Schriener, salesman, Wilson-Maeulen Co. then gave a demonstration on the Rockwell hardness tester, explaining in detail the construction and operation of the machine. A round table discussion was led by R. B. Kerr, Harvester plant, Deere & Co. on the committee report on the recommended practice for the heat treatment of carbon tool steel. Dinner was served at 7:00 p.m. preceding the meeting.

**WASHINGTON CHAPTER**

On Friday, Jan. 18, the Washington chapter of the American Society for Steel Treating held a meeting in the auditorium of the New Interior Department building. H. A. Schwartz, director of research, National Malleable Castings Co., Cleveland, gave an illustrated presentation entitled, "Malleable Iron." The speaker, who is nationally recognized as an authority on this subject, described the manufacture, properties and applications of malleable iron. His presentation was based on his wide practical experience and scientific research.

**WORCESTER CHAPTER**

The Worcester chapter of the American Society for Steel Treating held their January meeting at the Winter Garden of the Warren hotel. A. H. Kingsbury, Crucible Steel Company of America, Harrison, N. J. gave a very interesting paper on "Tool Room Problems." This was a very capable presentation and much valuable discussion was brought forth. After the discussion of this paper, John Bath, John Bath Co., Worcester, exhibited a number of samples of gages and plugs, and showed the manner in which inaccuracies occur when the gaging surfaces are oiled or wet in place of being dry. Dinner was served at 6:30 p.m. preceding the meeting.

ADDRESSES OF NEW MEMBERS OF THE AMERICAN SOCIETY FOR  
STEEL TREATING

EXPLANATION OF ABBREVIATIONS. M represents Member; A represents Associate Member; S represents Sustaining Member; J represents Junior Member, and Sb represents Subscribing Member. The figure following the letter shows the month in which the membership became effective.

ABORN, R. H. (Jr-1), Massachusetts Institute of Technology, Cambridge, mail 24 Groveland street, Auburndale, Mass.

ARDOVIN, L. R. (A-2), U. S. Steel Products Co., Los Angeles, Cal.

ARMSTRONG, W. E. (M-12), assistant technologist, Wheeling Steel Corp., Wheeling, W. Va., mail 624 Grant avenue, Martins Ferry, O.

BAILEY, ETHEL H. (M-12), in charge of material testing, L. W. F. Engineering Company, mail 86 MacDougal street, New York City.

BUCKINGHAM, R. B. (M-12), metallurgical department, Dodge Bros., mail 4429 Kerwin avenue, Detroit.

BURNS, N. M. (M-12), service department, Crucible Steel Company of America, mail 335 S. Pacific avenue, Pittsburgh.

CARNEY, J. J. (M-1), chief blacksmith, Saco-Lowell Shops, Newton Upper Falls, Mass.

CLARK, FRANCES HURD, (Jr-1), Massachusetts Institute of Technology, Cambridge, Mass.

CLEMENTS, D. S. (M-11), 210 Semple street, Pittsburgh.

CODDINGTON, F. A. (A-12), Crucible Steel Company of America, Buffalo.

COMSTOCK, G. F. (M-1), metallurgical engineer, Titanium Alloy Mfg. Co., Niagara Falls, N. Y.

DALY, J. F. (M-11), foreman tool room, Worthington Pump & Machinery Co., mail 29 Windemere road, Dorchester, Mass.

DANFORTH, H. A. (M-1), president Centrifugal Shock Absorber Co., mail 41 Market Square, West Lynn, Mass.

DE CORIOLIS, E. G. (M-1), industrial gas engineer, Eastern Service Co., mail 131 State street, Boston.

DE VAUX, D. H. JR., (Jr-1), student, Temple university, Philadelphia, mail 53 Windemere avenue, Lansdowne, Pa.

DYSON, A. (M-1), master mechanic, Saco-Lowell Shops, Newton Upper Falls, Mass.

FABEL, D. C. (Jr-1), student, Case School of Applied Science, mail 11428 Carolina road, Cleveland.

FAIRBANKS, P. G. (M-12), heat treating department, Simonds Saw Co., Fitchburg, Mass.

FLAHERTY, F. T. (M-12), chemical engineer, North East Electric Co., mail 291 Roxborough road, Rochester, N. Y.

FLAHERTY, J. H. (M-1), inspector, Jones & Laughlin Steel Corp., mail 3930 Vinceton street, Pittsburgh.

FLEISCHMAN, E. (M-11), heating engineer, Westinghouse Electric & Mfg. Co., East Pittsburgh, mail Westinghouse club, Wilkinsburg, Pa.

FREY, M. L. (M-1), assistant metallurgist, Holt Mfg. Co., mail 215 South Orange street, Peoria, Ill.

FRIEDL, H. G. (M-2), superintendent, McKair-Hatch, Inc., *mail* 1584 Niagara street, Buffalo.

GANTER, L. S. Jr., (M-1), purchasing agent, Ontario Silver Co., Muncie, Ind.

GOULD, G. K. (M-12), foreman metal saw hardening department, Simonds Saw Co., *mail* 47 Vernon street, Fitchburg, Mass.

GRETH, N. (M-11), metallurgical department, Bethlehem Steel Co., *mail* 226 Warren Square, Bethlehem, Pa.

GRIFFIS, R. O. (M-1), metallurgist, American Rolling Mill Co., Ashland, Ky.

GRUMBING, J. S. (A-11), salesman, Colonial Steel Co., Cleveland.

GUREVICH, L. J. (M-1), metallurgist, *mail* 635 Hague street, Detroit.

HALL, J. D. (A-1), salesman, Vanadium Alloys Steel Co., *mail* 1324 Estes avenue, Rogers Park, Chicago.

HENNES, R. P. (Jr-1), student, Case School of Applied Science, *mail* 9324 Talbot avenue, Cleveland.

HENRY, R. (M-1), president, Tri-City Steel Treating Co., *mail* 506 Forty-first street, Rock Island, Ill.

HERTZOG, R. R. (M-1), assistant chemist, Bethlehem Steel Co., *mail* 547 E. North street, Bethlehem, Pa.

HILL, J. W. (Jr-1), student, Case School of Applied Science, *mail* 2701 Adelbert road, Cleveland.

HOURIHAN, M. (M-12) foreman machine shop, Worthington Pump & Machinery Co., *mail* 8 Wyatt street, Somerville, Mass.

HUNTER, H. L. (Jr-1), 207 E. Madison avenue, Collingswood, N. J.

HUTCHINS, W. H. (M-12), assistant chief chemist, North East Electric Co., *mail* 92 Mason street, Rochester, N. Y.

IRETON, E. T. (J8-1, 2079 E. Atlantic street, Philadelphia.

IVES, L. G. (M-1), superintendent, steel mill, Wallace Barnes Co., Bristol, Conn., *mail* Forestville, Conn.

JONES, C. W. (M-12), charge tool heat treating, Deere Plow Co., *mail* 2953 Thirteenth avenue, Rock Island, Ill.

KING, V. (Jr-12), student, University of Pittsburgh, *mail* 417 S. Dithridge street, Pittsburgh.

KREKEL, E. C. (Jr-1), student, Case School of Applied Science, *mail* 4600 Lorain avenue, Cleveland.

LENNON, J. F. (A-12), sales, Bethlehem Steel Co., *mail* 15 Crawford St., Boston.

LEWIS, C. B. (M-1), metallurgist, Studebaker Corp., *mail* 42 E. Willis avenue, Detroit.

LIESKE, P. A. (M-12), machinist, Boston Elevated Railway Co., *mail* 11 Atherton avenue, Boston.

LINGEMANN, L. H. (A-1), power salesman, Duquesne Light Co., Pittsburgh.

MATTHEWS, I. C. (M-12), research chemical engineer, Eastman Kodak Co., *mail* 429 Clay avenue, Rochester, N. Y.

MAZURIE, V. M. (Jr-1), student, Case School of Applied Science, *mail* 15401 Macauley avenue, Cleveland.

MELAS, Wm. (M-1), laboratory technician, Standard Steel & Bearings Co., mail Box 102, Plainville, Conn.

MELLEN, J. A. (M-12), Watertown Arsenal, Watertown, Mass.

MELVILLE, N. F. (M-12), metallurgist, Columbia Steel Co., Elyria, O.

MOSES, B. J. (S-12), Gray & Davis, Inc., Cambridge, Mass.

MUELLER, O. W. (A-2), assistant to president, Brace-Mueller-Huntley, Inc., 851 Ellicott Square, Buffalo.

NEUHAUS, R. (M-12), engineering department, Hughes Tool Co., Houston, Tex.

NIPHER, E. T. (M-1), plant manager, Ames Shovel & Tool Co., mail Box 443, Anderson, Ind.

O'CONNELL, J. C. (M-12), foreman, heat treating, Willys Morrow Co., mail 205 Horner street, Elmira, N. Y.

O'REILLY, C. L. (M-1), inspector Ford Motor Co., Rouge plant, Detroit, mail 2418 Fifth street, Detroit.

OSTERBERG, A. V. (M-1), forge shop, Studebaker Corp., mail 742 Lincoln Way, East, South Bend, Ind.

PEACOCK, S. (M-11), Wheeling Steel Corp. building, Wheeling, W. Va.

PHILLIPS, J. A. JR., (A-12), salesman, Carpenter Steel Co., mail 704 Commonwealth avenue, Boston.

RUSSELL, A. (M-1), inspection department, United Alloy Steel Co., mail 1009 Bluff road, Canton, O.

SHERLOCK, R. E. (M-1), metallurgical engineer, Donner Steel Co., Buffalo.

SIMPSON, T. I. (M-12), chief inspector, Worthington Pump & Machinery Co., Boston, mail 139 Fresh Pond Parkway, Cambridge, Mass.

SMITH, E. JR. (M-12), Edison Storage Battery Co., Orange, N. J.

SMITH, W. M. (A-12), salesman, Calorizing Corp., 50 Church street, New York City.

STRAND, D. P. (A-1), Salesman, Hawkridge Bros. Co., Boston, mail P. O. Box 566, Worcester, Mass.

TAYLOR, H. S. (M-1), chief metallurgist, Holt Mfg. Co., Stockton, Cal.

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#### MAIL RETURNED

CHAMBERLAIN, G. D., American Chain Company, Bridgeport, Conn.

ESAU, G. W., 5714 Blackstone Avenue, Chicago.

FLANNERY, MICHAEL, Royal Typewriter Co., 150 New Park Ave., Hartford, Conn.

HUSTED, M. R., 1809 W. Warren Ave., Chicago.

MITCHELL, D. E., Dodge Bros. Co., Detroit.

## Items of Interest

**R**OBERT M. BIRD has resigned his position with Bethlehem to associate himself with George F. Pettinos of 1206 Locust street, Philadelphia, in the business of sand, gravel, foundry supplies and plumbago.

Well known as a prominent member of the Bethlehem Steel Co.'s metallurgical staff, Mr. Bird is also widely known in iron and steel circles throughout the country, particularly wherever automobile and other high grade steels are manufactured, heat treated and used.

Mr. Bird is a vice president of the American Society for Steel Treating and is a member of the Standards Committee of the Iron and Steel Division of the Society of Automotive Engineers. In the American Society for Test-



ROBERT M. BIRD

ing Materials, he is a member of several committees charged with providing national specifications for quality steels.

Graduated with high standing as a mechanical engineer at Lehigh university in 1902, he came into the Bethlehem Steel Co. through the "Loop Course." This means that he was one of a selected number of college graduates chosen for scholarship and for character who have had every opportunity to study in succession the many phases of the company's business.

Steel treating was not then widely known nor thoroughly developed. Only a few steel making organizations, had knowledge of this science. Mr. Bird soon became connected with the Bethlehem company's heat treatment department. In less than three years he became its superintendent. In this position for a dozen years he established a reputation for ability in develop-

ing the theory and perfecting the practice of steel treatment. At the end of the war he was appointed metallurgist at the Bethlehem plant and later engineer of tests.

The management of the company regrets his departure and their hearty good wishes follow him.

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A. P. Spooner who succeeds R. M. Bird as engineer of tests of the Bethlehem plant of Bethlehem Steel Co. has been in their employ since 1915 in the metallurgical division working under R. M. Bird and his predecessor, W. R. Shimer.

Mr. Spooner received the degree of metallurgical engineer at Lehigh university in 1911. After graduation he was employed in the blast furnace department of the Pennsylvania Steel Co. who at that time were carrying on



A. P. SPOONER

a considerable amount of experimental work. In 1912 he became identified with the Canadian Collieries Co., Ltd., Union Bay, Canada, working in their coal washery and loading plant until 1913.

During the first year of the war he became connected with the inspection department of the Harrisburg Pipe & Pipe Bending Co. who were working on shell orders. He was with them until 1915 when he became associated with Bethlehem Steel Co. where he has had occasion to keep in close contact with all their products.

Mr. Spooner is a member of the American Institute of Mining & Metallurgical Engineers, the American Society for Testing Materials, and chairman of the Lehigh Valley chapter of the American Society for Steel Treating.

The United States Civil Service Commission announces open competitive examinations for positions of laboratory assistant, junior grade, \$1000 a year and senior aid, \$900 a year.

The examinations will be held throughout the country on March 5. They are to fill vacancies in the Bureau of Standards, Department of Commerce, at the entrance salaries named above, plus the increase of \$20 a month granted by Congress, and vacancies in positions requiring similar qualifications.

The commission also announces open competitive examinations for positions junior aid, grade 1, \$540 a year and junior aid, grade 2, \$720 to \$840 a year. These examinations will be held on March 5. They are to fill vacancies in the Bureau of Standards, Department of Commerce.

On March 5 civil service examinations will be held for positions of laboratory assistant, senior grade, \$1200 to \$1380 and for junior engineer, junior physicist and junior technologist, \$1200 to \$1500 a year. These examinations are given to fill vacancies in the Bureau of Standards, Department of Commerce.

Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of United States civil service examiners at the post office or custom-house in any city.

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At a meeting of the board of directors of the American Foundrymen's association, held in New York, Nov. 20, it was unanimously voted to hold the next convention of the association and exhibit of foundry equipment in the fall of 1924, preferably in the month of October.

From 1911 to 1920 the annual meetings of the association were held in September or October of each year. Due to business conditions in 1921, it was decided to postpone the meeting until the spring of 1922 and a convention was held at Rochester, N. Y., in June of that year and again at Cleveland in May, 1923. There has been a feeling on the part of many that fall dates were most desirable, and a number of good arguments have been presented in support of this change.

In considering location, it was felt that the Central West was the logical place, as the Milwaukee convention in 1918 was the only one which has been held west of Cleveland since the Chicago convention in 1914. The selection of a city was left to a special committee appointed by the president. The cities from which invitations have been received and which were given favorable consideration alphabetically listed are Chicago, Detroit, Indianapolis, Kansas City and Milwaukee. The facilities which these cities have to offer in the way of hotel accommodations, meeting rooms and exhibition buildings will be investigated and decision reached, announcement of which will probably be made some time in January.

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Announcement has been made of the opening of a drop forge plant under the name of Bay State Forge Co., Highland Station, Springfield, Mass. who have modern and complete equipment for drop forging, heat treating and die sinking as well as excellent receiving and shipping facilities. J. H. G. Williams, formerly of Billings & Spencer, Hartford, Conn., is general manager of the company.

On Jan. 1, N. M. Salkover resigned his position as metallurgist of the R. K. LeBlond Machine Tool Co., Cincinnati, to organize his own company which is to be known as the Metallurgical Service Co. with offices at 405 Mercantile Library building, Cincinnati. The purpose of this company is to intelligently sell a complete line of metallurgical equipment and supplies to the industries. In addition to merely selling, Mr. Salkover, through training and experience, is well qualified to give engineering advice and service.

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According to an announcement from Carnegie Institute of Technology in Pittsburgh, a fellowship in metallurgy has just been established by the department of metallurgical and mining engineering, and an appointment is to be made immediately. The fellowship will be under the general supervision of the advisory board of the department of metallurgical and mining engineering. The first problem to be studied under the fellowship is "an investigation of the effects of small percentages of phosphorus on the physical properties of low carbon steel especially under alternating stresses and shock." In his investigations, says the announcement, the appointee will be given the full co-operation of the members of the advisory board, which was recently organized and includes a prominent group of Pittsburgh district engineers and industrial executives.

The fellowship pays \$750 for the ten months of the college year. As an appointment will be made promptly for the remainder of the college year, applications are now being solicited. Candidates are requested to address W. E. Mott, director, college of engineering, Carnegie Institute of Technology.

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William C. Buell Jr. of the firm, Buell, Schieb, Mueller, Inc., specializing in furnace design, has joined the engineering staff of the Chapman-Stein Furnace Co., Mount Vernon, O. From 1906 to 1914 he was engineer with the Westmacott Furnace Co. and later was engineer of tests with Tate, Jones & Co. After two years' service in the engineers' corps during the World war, he returned to Tate, Jones & Co.

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Roy H. Davis, general manager Firth-Sterling Steel Co., Pittsburgh, has returned from a trip to Sheffield, England, where he has been investigating new developments in the manufacture and application of stainless steel. J. Wortley Fawcett and Eric Holmstrom of Thos. Firth & Sons, Ltd., Sheffield, returned with Mr. Davis in the interest of the latter company's business in this country.

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Louis J. Campbell, son of President James A. Campbell of the Youngstown Sheet & Tube Co., this week submitted to the amputation of his left leg below the knee. The operation was performed in New York.

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The Ronald Press Co., New York City, have recently published a book by Alvan T. Simonds, president, Simonds Saw & Steel Co. entitled, "Business Fundamentals." For twenty-five years, the author has been studying the

(Continued on Page 34 Advertising Section)

